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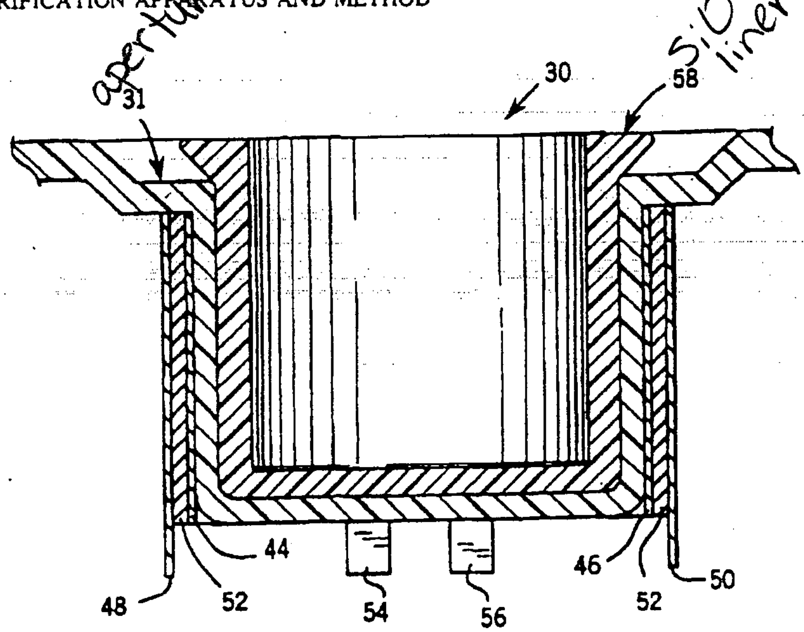

(57) Abstract

Embodiments disclosed herein provide apparatus and methods for verifying a volume of fluid. According to one embodiment, an apparatus includes a receptacle for containing fluid, a first conductor operatively associated with the receptacle and a second conductor operatively associated with the receptacle offset from the first conductor. A source of a first electrical signal is electrically connected with the first conductor. A monitor is electrically connected with the second conductor for detecting a second electrical signal created in the second conductor. In another embodiment, a method includes positioning a receptacle adjacent a fluid dispense nozzle such that fluid dispensed from the nozzle enters the receptacle. A first electrical signal is applied to a first conductor operatively connected with the receptacle. A second electrical signal created in a second conductor operatively connected with the receptacle responsive to the first electrical signal is monitored.

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VOLUME VERIFICATION APPARATUS AND METHOD

BACKGROUND OF THE INVENTION

Embodiments of the present invention generally relate to an apparatus and a method for checking or verifying a volume of a fluid. More specifically, the embodiments relate to an apparatus and a method for verifying fluid volume for use in an automated instrument.

Automated instruments are available to perform a number of tasks. One such automated instrument is an analytical instrument. An analytical instrument can perform tests, such as medical diagnostic tests, on a sample. For example, such tests may identify the AIDS virus in a blood sample or other item of interest in a biological sample.

To perform such tests, an analytical instrument may mix the biological sample with a substance, such as a reagent and the like. In some embodiments, these reagents may be fluids. The fluids may be supplied to the biological sample within the medical instrument by a fluid system. The fluid system may include a source of fluid, a pump, a dispense nozzle and a conduit fluidly connecting those elements. The source of fluid may be a container and the like. The pump moves fluid from the

container toward the dispense nozzle through the conduit. The sample, which may be held in a suitable container, is positioned adjacent the dispense nozzle. When the pump is operated, fluid from the container leaves the nozzle and enters the sample container. Movement of the fluid into the container, if desired, can cause the fluid and the sample to mix.

Illustrating further by example, a given instrument may perform a blood analysis. The instrument adds a predetermined volume of a fluid to a predetermined volume of a blood sample. The fluid reacts with the blood sample. Because of the reaction between the sample and the fluid, an electromagnetic or chemi-optical signal or light is sent from the mixture of sample and fluid. A detector in the instrument sees or reads the light sent from the mixture. Appropriate elements of the instrument, such as a computer and the like, interpret the information obtained by the detector and provide an operator with information about the blood sample.

In order for this instrument to perform as intended and to give accurate results, it is desirable that a specific, predetermined amount or volume of fluid be mixed with the sample. If too much or too little fluid were added to the sample, the light sent from the mixture may be different from the proper light sent from the mixture when the predetermined volume of fluid is added. The different light sent from the mixture is interpreted by the computer in the same way as the proper light. Therefore, the computer may give inaccurate information to the operator of the instrument.

The possibility of inaccurate information being given by an instrument is a concern. For example, the test performed may be to see if a unit of blood were infected with the AIDS virus. Assuming that the blood is infected with the AIDS virus, adding too little or too much fluid to the blood sample may result in the instrument telling the operator that the unit of blood is not infected with the AIDS virus. Accordingly, it can be appreciated that it is desirable to have an apparatus

connectable with the instrument for checking elements of a fluid system and for verifying that the proper, predetermined amount of fluid has left the dispense nozzle and entered the container during operation of the analytical instrument.

SUMMARY OF THE INVENTION

Embodiments disclosed herein provide apparatus and methods for verifying a volume of fluid. According to one embodiment, an apparatus includes a receptacle for containing fluid, a first conductor operatively associated with the receptacle and a second conductor operatively associated with the receptacle offset from the first conductor. A source of a first electrical signal is electrically connected with the first conductor. A monitor is electrically connected with the second conductor for detecting a second electrical signal created in the second conductor.

In another embodiment, a method includes positioning a receptacle adjacent a fluid dispense nozzle such that fluid dispensed from the nozzle enters the receptacle. A first electrical signal is applied to a first conductor operatively connected with the receptacle. A second electrical signal created in a second conductor operatively connected with the receptacle responsive to the first electrical signal is monitored.

In a further embodiment, a method comprises placing a volume of fluid within a receptacle. A first conductor is positioned adjacent the receptacle such that the first conductor does not contact the volume of fluid. A second conductor is positioned adjacent the receptacle such that the second conductor does not contact the volume of fluid or the first conductor. A first electrical signal is applied to the first conductor. A second electrical signal generated in the second

conductor responsive to the first electrical signal is monitored to verify the volume of the fluid in the receptacle.

In an additional embodiment, an apparatus for verifying a volume of fluid comprises a receptacle for containing fluid. A first conductor is operatively associated with the receptacle such that the first conductor does not contact the volume of the fluid. A second conductor is operatively associated with the receptacle offset from the first conductor such that the first conductor does not contact the volume of the fluid. A source of a first electrical signal is electrically connected with the first conductor. A monitor is electrically connected with the second conductor for detecting a second electrical signal created in the second conductor.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a block diagram view of a volume verification apparatus disclosed herein;

Fig. 2 is an enlarged plan view of a portion of the apparatus of Fig. 1;

Fig. 3 is a sectional view, along line 3-3 of Fig. 2;

Fig. 4 is an enlarged sectional view of a portion of the apparatus shown in Figs. 2 and 3;

Fig. 5 is a plan view of an element of the apparatus shown in Fig. 4;

Fig. 6 is a side elevational view of a portion of the element shown in Fig. 5;

Fig. 7 is a block schematic diagram of a portion of the apparatus of Fig. 1;

Fig. 8 is a generic block diagram of a portion of the apparatus of Fig. 1;

Figs. 9A and 9B are schematic diagrams of elements of the portion illustrated in Fig. 7;

Fig. 10 is a schematic diagram of elements of the portion illustrated in Fig. 7;

Fig. 11 is a schematic diagram of elements of the portion illustrated in Fig. 7; and

Fig. 12 is a schematic diagram of elements of the portion illustrated in Fig. 7.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

The embodiments disclosed herein relate to an apparatus and a method for verifying a volume of fluid. The embodiments may be used with any desired fluid with suitable modifications to provide compatibility with the desired fluid, e.g. non-reactivity. The embodiments may be utilized in any suitable employment. For the sake of clarity, the embodiments are discussed with respect to their employment with an analytical instrument. The analytical instrument may be substantially similar to those disclosed in U.S. Patent No.'s 5,006,309, 5,015,157, 5,089,424, 5,120,199, Des. 332,834, 5,185,264, 5,198,368, 5,232,669, 5,244,630, 5,246,354, 5,283,178, 5,299,446 and 5,151,518. Those patents are assigned to the assignee of the present invention and the disclosures thereof are incorporated herein by reference. It is to be noted that the embodiments disclosed herein may be modified in any desirable fashion to produce still other embodiments. For instance, steps of one method may be combined, in any desired order, with steps of another method to arrive at yet another method.

Fig. 1 illustrates a volume verification apparatus 10 which verifies a volume of a fluid, such as a reagent, a sample and the like. It is to be noted that the apparatus 10 verifies fluid volume without requiring an electrode or conductor to come into physical contact with the volume of fluid being verified. This property of the apparatus 10 is advantageous, i.e. to reduce fluid carryover and the like.

The apparatus 10 generally comprises a sensor unit 12, a feedback mechanism 14 and a source 16 of electrical energy. The sensor unit 12 is operatively connectable with an analytical instrument 18 for verifying a fluid volume associated with the analytical instrument 18. The sensor unit 12 is electrically connected with the feedback mechanism 14 by conductor 20. Conductor 22 electrically connects the feedback mechanism 14 with the source 16 of electrical energy such that the feedback mechanism 14 and the sensor unit 12 are supplied with electrical energy. In some embodiments, a conductor 24 is provided that electrically connects the feedback mechanism 14 to a computer 26. In other embodiments, a conductor 28 is provided which electrically connects the computer 26, in parallel, with the analytical instrument 18. In still further embodiments, the conductor 28 may directly electrically connect the feedback mechanism 14 with the analytical instrument 18, which may integrate the computer 26.

The sensor unit 12 includes at least one receptacle 30 for containing a volume of fluid to be verified. The sensor unit 12 may have a configuration which corresponds to a complementary configuration on the analytical instrument 18 to provide compatibility. The feedback mechanism 14 includes structures, such as a display 32 and the like, for providing an operator with feedback indicative of the volume of fluid to be verified. The feedback mechanism may also be provided with a switch 34 for selecting electrical connection between the sensor unit 12 and the source 16 of electrical energy. The computer 26 includes memory containing and running appropriate routines to control operation of the apparatus 10 and to utilize the feedback provided by the feedback mechanism 14.

Fig. 2 illustrates the sensor unit 12 in more detail. The sensor unit 12 contains at least one receptacle 30 for containing a volume of fluid to be verified and a circuit board 35. The receptacle 30 is defined by an aperture 31 on the sensor unit 12. The number of receptacles 30, as well as their

disposition is dependent upon the construction of relevant portions of the analytical instrument 18. The circuit board 35 is supported in a housing 36 by suitable structures. The circuit board 35 may be accessed from an exterior of the housing 36 through panel 38 which may be removable from the housing 36. The housing 36 also comprises a port 40 for accepting the conductor 20 thereby permitting electrical connection between the circuit board 35 and the feedback mechanism 14. In one embodiment, the housing 36 is substantially rectangular having a length of about 6.5 inches, a width of about 3 inches and a height of about 0.9 inches. In the illustrated embodiment, six receptacles 30 are formed in the housing 36, however, other numbers are also possible.

An exemplary receptacle 30, illustrated in Fig. 4, comprises a first conductor 44 and a second conductor 46 operatively associated with the aperture 31. In a exemplary embodiment, the first conductor 44 may be a transmitter while the second conductor 46 may be a receiver. The first conductor 44 and the second conductor 46 include, respectively, contacts 54 and 56 that permit electrical connections with the first conductor 44 and the second conductor 46.

The contacts 54 and 56 allow an electromagnetic signal to be sent to or from the conductors 44 and 46, respectively. The first conductor 44 and the second conductor 46 are electromagnetically coupled such that electromagnetic signal transmission between the first conductor 44 and the second conductor 46 depends upon a substance, such as a volume of fluid and the like, operatively disposed between the first conductor 44 and the second conductor 46. By appropriately consulting electromagnetic signal transmission between the conductors 44 and 46, an operator can determine or verify a volume of fluid contained within the receptacle 30, i.e. the volume of fluid dispensed by the analytical instrument 18.

An exemplary construction of the conductors 44 and 46 is illustrated in Figs. 5 and 6. The conductors 44 and 46 are

formed from pieces or sheets of a suitable metal, such as copper and the like. The conductors 44 and 46 are formed or curved in a substantially semicylindrical shape. In one embodiment, the conductors 44 and 46 define a diameter of about 0.5 inches and have a height of about 0.5 inches and a thickness of about 0.01 inches. The contacts 54 and 56 depend from the substantially semicylindrical bodies of the conductors 44 and 46. The contacts 54 and 56 are about 0.08 inches wide and about 0.125 inches long. As shown in Fig. 5, the first conductor 44 is offset from the second conductor 46 by a gap 60 measuring about 0.05 inches.

Some embodiments include a third conductor 48 and a fourth conductor 50, operatively associated with the first conductor 44 and the second conductor 46, respectively, to reduce electromagnetic interference received by the first conductor 44 and the second conductor 46. In these embodiments, an insulator 52 may be disposed electrically between the first conductor 44 and the third conductor 48 and electrically between the second conductor 46 and the fourth conductor 50. In some embodiments, the third conductor 48 and the fourth conductor 50 may be integrated as a single conductor.

The aperture 31 associated with a particular receptacle 30 provides support for the conductors 44 through 50 and the insulator 52. In some embodiments, the conductors 44 through 50 and the insulator 52 may be removed from the associated aperture 31 for cleaning, replacement, etc.

In still further embodiments, a liner 58 may be disposed within the aperture 31 at a side thereof opposite to the side thereof adjacent the conductors 44 and 46. The liner 58 may be made from a material that is compatible, e.g. non-reactive, with the fluid, a volume of which is to be verified by the apparatus 10. In some embodiments, the liner 58 may be removable for replacement, cleaning, etc. In other embodiments, the liner 58 may be a coating or other treatment applied to the aperture 31. In still other embodiments, the liner 58 may be provided on an

inner surface of a removable insert which is removably connectable with the aperture 31. The insert may be made of a suitable, non-electrically conducting polymer, such as Monsanto Lustran 248.

In one embodiment, the liner 58 comprises a low friction substance, such as a silicone and the like, to reduce a meniscus curvature formed by a fluid disposed within the liner 58 and thereby within the receptacle 30. In an exemplary embodiment, the liner 58 comprises a polymeric coating, such as dimethyl-hydroxyl-alkylene-oxide-methyl-siloxane (United Chemical Technologies #PS835, Bristol, PA). If a removable insert were used, then, in one embodiment, at least one insert is placed in a mixture of silicone or about 2.0 grams of dimethyl-hydroxyl-alkylene-oxide-methyl-siloxane and about 98 grams of trichlorotrifluoroethane (Baxter Scientific Products MS-80902, Sunnyvale, CA). The insert is removed from the mixture and drained. The insert is dried at about 80 degrees Celsius for about 2 hours. The insert is rinsed. Then, the insert is placed in a bath of distilled water for about 5 minutes and the insert is drained. The insert is dried again at about 80 degrees Celsius for about 2 hours. The liner 58 and/or the insert is substantially cylindrical, having an open end and a closed end, with an inner diameter of about 0.51 inches, an outer diameter of about 0.59 inches and a height of about 0.56 inches.

An exemplary embodiment of electronic structure or circuit 61 associated with the sensor unit 12 is illustrated generally in Fig. 7, with detailed electronic schematic diagrams presented in Figs. 8 through 12. An oscillator 62 generates a periodic electrical signal substantially in the radio frequency range. In an exemplary embodiment, the oscillator 62 generates a substantially square wave of about 1.58 Volts peak-to-peak with an approximate 3.6 Volts (DC) offset at a frequency of about 100 kHz. An exemplary embodiment of the oscillator 62 is shown in Figs. 9A and 9B.

The oscillator 62 is electrically connected to a filter 64 (bandpass) with a passband of about 60 kHz centered at about 100 kHz. The filter 64 converts the periodic signal from the oscillator 62 to an electrical signal of substantially similar frequency but of approximately sinusoidal form. The construction of the filter 64 is shown in Figs. 9A and 9B. The filter 64 is electrically connected to an amplifier 66, also shown in detail in Figs. 9A and 9B, which increases an amplitude of the electrical signal by a factor of about 7.5, yielding an approximately 11.0 Volt peak-to-peak (AC) signal of about 100 kHz.

Electrical output of the amplifier 66 is electrically connected to a switch 68 (Fig. 10), such as a multiplexer and the like, which directs the signal to the conductor 44 associated with at least one receptacle 30 (Fig. 4) or to one of two reference resistor circuits 70. Electromagnetic coupling between the conductor 44 and the conductor 46, due at least in part to electrical transmissive properties of the fluid, causes an electrical signal to be received by the conductor 46. The amplitude of the electrical signal received by the conductor 46 is a function of fluid volume within the receptacle 30. The reference resistor circuits 70 may be voltage dividers, such as an about 10 kΩ resistor and an about 700 Ω resistor electrically connected in series, to yield an output voltage that is a known and substantially constant fraction of an input voltage.

The electrical signal received by the conductor 46 is electrically connected via a buffer 72 (Fig. 12) to the switch 68. The switch 68 electronically connects the conductor 46 from the selected receptacle 30 to the remainder of the circuit 61. The switch 68 may be a dual multiplexer with an address input 74 (Fig. 10) from the feedback mechanism 14 or may be two multiplexers controlled so that both the conductor 44 and the conductor 46 associated with a given receptacle 30 are connected to the circuit 61 simultaneously.

The electrical signal from the switch 68 is electrically connected via an amplifier 76 to a filter 78 (bandpass). The amplifier 76 has a gain of about 20. The filter 78 has a passband of about 60 kHz centered at about 100 kHz. The filter 78 is electrically connected with a buffer 80. The output of the buffer 80 feeds into a rectifier 82 (full wave) and an integrator 84 (active). Details of the amplifier 76, the filter 78 and the buffer 80 are illustrated in Figs. 9A and 9B. Details of the rectifier 82 and the integrator 84 are shown in Fig. 11.

The output of the integrator 84 is a substantially steady direct current voltage which is approximately linearly related to an amplitude of the electrical signal received by the conductor 46. This output is indicative of a volume of fluid disposed in the selected receptacle 30. This direct current voltage is applied to an amplifier 86 (Fig. 11), with a gain of about 5, that imposes an adjustable offset of the order of about 8.8 Volts (DC). The offset, controlled by an adjustable reference voltage circuit 88 (Fig. 11), is set prior to use of the apparatus 10 by substantially filling all of the associated receptacles 30 with about 350 µl of a fluid, such as degassed, deionized water and the like, and adjusting the offset so that all receptacles 30 yield an output voltage of about 0.0 Volts (DC). The output of the amplifier 86 is an electrical signal that varies between about 0 Volts (DC) and about +5 Volts (DC). The output of the amplifier 86 is transmitted along conductor 90 to the feedback mechanism 14.

The feedback mechanism 14, shown in Fig. 8, generally contains an analog to digital converter 92 which, in this embodiment, is a 17 bit converter with sign. The converter 92 converts the output voltage from the sensor unit 12 to a numerical value. The feedback mechanism 14 also includes the display 32 to display the numerical value from the converter 92 or another numerical value. The feedback mechanism 14 also includes a energy supply unit 94 to receive electrical energy

from the source 16 of electrical energy to supply electrical energy to the components of the feedback mechanism 14 and the sensor unit 12. The feedback mechanism 14 also may contain data processing circuitry 96 (such as a microcontroller and the like) to control operation of the apparatus 10, an input/output circuit 98 which acts as an interface between the feedback mechanism 14 and the sensor unit 12, and communication circuitry 100 (such as an RS-232 serial transfer device and the like) to transmit data to the computer 26 or some other device for further processing, evaluation, or storage.

In this embodiment, the microcontroller 96 sends a three-bit binary address signal via the input/output circuit 98 to the sensor unit 12 that corresponds to the desired receptacle 30 or reference resistor circuit 70. The three-bit binary address signal is applied to the address lines 74 of the switch 68. The electrical signal indicative of the volume of fluid disposed in the selected receptacle 30 is applied to the analog to digital converter 92. The analog to digital converter 92 produces a digital numerical signal which is transmitted via the communication device 100 to the computer 26 and may also be displayed on the display 32.

With the construction of an embodiment of an apparatus for verifying a volume of a fluid being disclosed in detail, an embodiment of a method of verifying a volume of fluid or operation of the apparatus 10 will now be disclosed. For the sake of clarity, the methods will be discussed in relation to the apparatus 10. However, the methods may be employed with any suitable mechanism. A plurality of methods are detailed.

In general, one method of checking or verifying a volume of fluid comprises the following steps. The apparatus 10 is positioned with respect to the analytical instrument 18 such that a receptacle 30 is operatively connected with a fluid dispense nozzle on the instrument 18. The operative connection between the receptacle 30 and the dispense nozzle is such that fluid exiting the dispense nozzle enters the receptacle 30.

Fluid exits the dispense nozzle and enters the receptacle 30. An electrical signal is applied to the conductor 44. An electrical signal is created in the conductor 46 responsive to the electrical signal applied to the conductor 44. The electrical signal created in the conductor 46 is monitored. Because an amplitude of or a voltage associated with the electrical signal created in the conductor 46 is related to the volume of fluid present in the receptacle 30, appropriate monitoring of the electrical signal created in the conductor 46 provides an indication of the volume of fluid within the receptacle 30. The apparatus 10 provides feedback to an operator or a computer corresponding to the volume of fluid within the receptacle 30.

More specifically, the following methods can be used along with the apparatus 10, or an equivalent device, to verify a volume of fluid.

System calibration

The apparatus 10 may be calibrated by performing the following method steps.

1. Using a mass balance, determine a volume of fluid dispensed by a precision test pump. In one embodiment, the volume of fluid measures about 50 µl. The test pump may be a valveless metering pump such as that described in U.S. Patent No. 5,246,354. That patent is assigned to the assignee of the present application. The disclosure of that patent is incorporated herein by reference. The pump should be primed prior to use.

2. Install liners 58 in apertures 31 in the sensor unit 12 and rinse the liners 58.

3. Fill all receptacles 30 with about 350 µl of degassed, deionized water.

4. Adjust the reference circuit 88 so that the digital output of the analog to digital converter 92 for all channels is greater than about -45,000.

5. Make about 6 additions, measuring of about 50 µl each, of degassed, deionized water to each receptacle 30 from the precision test pump. While making these additions, monitor the output of the analog to digital converter 92.

6. Calculate the average change in output of the analog to digital converter 92 for each addition of degassed, deionized water to each of the receptacles 30. The slope is approximately equal to the difference in counts between a period following the initial dispense of about 350 µl of water and a period after the about 6 additional dispenses of water multiplied by 50 and divided by the actual volume dispensed (6 times the precision test pump dispense volume). This slope may be used for volume verification and may be stored in an appropriate memory, such as a RAM, a ROM, an EPROM, a SRAM and the like, which may be located in the feedback mechanism 14.

Volume verification

To verify a volume of fluid dispensed by a pump in an analytical instrument 18 with the apparatus 10, the apparatus 10 is calibrated as discussed above. After calibration, the following steps are performed.

1. Install new liners 58 in the sensor unit 12.

2. Prime the dispense pump by dispensing fluid from the dispense pump at least about 10 times.

3. Make available the slope data, determined during calibration, for the sensor unit 12.

4. Add about 350 µl of degassed, deionized water to each of the receptacles 30.

5. Make 6 additions of about 50 µl each of degassed, deionized water to each receptacle 30 from the precision test pump. While making these additions, monitor the output of the analog to digital converter 92.

6. For each dispense, calculate the volume of the dispensed water by multiplying the difference in counts from the analog to digital converter 92 before and after the dispense by 50 µl and by dividing by the slope determined in the calibration process.

7. Calculate the mean and the coefficient of variation of the dispensed volume.

In an example of the above method steps, a test pump was adjusted to dispense about 47.5 µl of degassed, deionized water, as measured by a mass balance. In 12 verification runs, the average error detected by the apparatus 10 was about 0.21 µl or about 0.42 percent (with a range of about 0.0 µl to about 0.63 µl or substantially within the range of about 0.0% to about 1.26%). The coefficient of variation of dispensed volume readings within the twelve runs averaged about 0.88 percent (with a range of about 0.18% to about 1.95%).

<u>Automated reading</u>

An example of software that may be used to operate or process information from the apparatus 10 is presented at the end of this discussion and preceding the claims. This software, written in structured BASIC, may be executed by the computer 26 which may or may not be integrated with the instrument 18. The routine performs the following steps. Relevant portions of the

routine are flagged by **STEP** and the number of the step, which corresponds to the numbers below.

1. Establish communication via the communication circuit 100 between the computer 26 that is executing the software routine and the feedback mechanism 14.

2. Select a receptacle 30. A data packet indicating this receptacle 30 is transmitted to the feedback mechanism 14. The feedback mechanism 14 converts this data packet to a three-bit digital address signal that is transmitted to the sensor unit 12 via the address lines 74.

3. The digital output from the analog to digital converter 92 of the feedback mechanism 14 is received by the computer 26 via the communication circuit 100. This step is executed in the subroutine entitled "RCV," which contains two steps.

   3a. Each serial data packet, in one embodiment one byte representing an ASCII character, from the communications circuit 100 of the feedback mechanism 14 is received as a character value.

   3b. The data received from the communication circuit 100 is appended to preceding data packets to form a character string. The signal normally consists of a series of ASCII characters, the first eight of which are the decimal value of the analog to digital converter 92 output and the ninth which is the decimal value of a channel number, which corresponds to a location on the analytical instrument 18. The seven most significant digits of the analog to digital converter 92 output are used in volume calculations.

4. The character string is converted to two numerical values representing the analog to digital converter 92 output and the channel number.

5. The volume of dispensed fluid is displayed and/or printed.

Automated verification of dispense volume of fluid

A software routine that may be used with an embodiment of an apparatus to verify a volume of fluid is presented before the claims. This software routine, written in structured BASIC, may be executed on a computer 26. This routine incorporates the routines described above to determine output of the analog to digital converter 92 with additional routines included to execute the following steps.

1. Communication is established via a serial data link between the computer 18 that is executing the software routine and the feedback mechanism 14.

2. The value of the calibration slopes for the various receptacles 30 are read from a preexisting data file. This data file was created using a procedure similar to that described with respect to System calibration.

3. Communication is established between the computer 26 that is running the software routine and the analytical instrument 18.

4. A receptacle 30 is selected for performing verification of a dispensed volume of fluid. This selection may be made by the operator directly or by a routine associated with the analytical instrument 18.

5. The output of the analog to digital converter 92 is monitored by the routine during an initial dispense of about 450 µl of fluid into the receptacle 30. The output values are read using the routines described above.

6. The output of the analog to digital converter 92 is allowed to stabilize.

7. Readings from the reference resistor circuits 70 are taken.

8. The output of the analog to digital converter 92 is monitored by the routine during dispense of about 50 µl of fluid into the receptacle 30. There may be a plurality of such dispenses. The output values are read using the routines described above, located in subroutines "DBLREAD" and "RCV."

9. The output of the analog to digital converter 92 is allowed to stabilize.

10. The numerical value of the analog to digital converter 92 output is stored in suitable memory, such as a RAM, a ROM, an EPROM, a SRAM and the like.

11. Steps 8-10 are repeated for the desired number, such as 6, of dispenses of fluid in the selected receptacle 30.

12. Readings from the reference resistor circuits 70 are taken.

13. The difference in the analog to digital converter 92 output, representing the volume of fluid associated with each dispense, is calculated.

14. The mean dispense volume and standard deviation of the dispense volumes are calculated, along with the deviation from the mean for each individual dispense. This step is executed within the subroutine "CALCULATE."

15. For each of the dispenses performed and verified, the volume of the dispense of fluid is calculated, is printed and/or is displayed and is stored in a record file.

16. The mean and standard deviation of the dispensed volume for all dispenses are printed.

17. The mean and coefficient of variation are compared to a predetermined "pass" criteria.

The methods discussed herein may be controlled or executed manually or by a controller, such as the computer 26 and the like, or may be controlled by software residing on and running within memory comprising the analytical instrument 18. By verifying a dispensed volume of fluid, an implicit test of the fluid delivery system, comprising a fluid source, a pump, a fluid conveying conduit, a dispense nozzle, etc., is made. Thus, the apparatus and method described herein may give an operator an indication of status of elements of a fluid system associated with the analytical instrument 18.

A listing of the above-discussed software routines follows presently. The **STEP** numbers correlate to the numbers used in the above discussion.

```
STEP 1
'*******************INITIALIZE METER INTERFACE*******************
OPEN "COM1:9600,N,8,1,BIN,CD0,CS0,DS0,RS,TB256,RB32000" FOR
RANDOM AS #1'RF METER SERIAL CONNECTION
CALL Delay(300)

x = INP(&H3FC)    ' set CTS and DTR
x = x OR 3
OUT &H3FC, x
```

```
DBLREAD:
'*********inner read loop

 VIEW PRINT 14 TO 23
 LOCATE (14 + j), 1
 IF j > 0 THEN PRINT USING "      ##        "; j;
```

STEP 2

```
SELECT CASE chan
 CASE 1: PRINT #1, "M4"
 CASE 2: PRINT #1, "M1"
 CASE 3: PRINT #1, "M3"
 CASE 4: PRINT #1, "M0"
 CASE 5: PRINT #1, "M5"
 CASE 6: PRINT #1, "M2"
 END SELECT

CALL RCV
 CALL Delay(READDEL) 'delay for apres mux

 PRINT #1, "R"
```

STEP 3

```
CALL RCV
 '*********
 S$ = MID$(sbuff$, 3, 10) + " "
 S = VAL(LEFT$(S$, 8)) / 32

 oldchana = chana
```

STEP 4

```
chana = VAL(LEFT$(S$, 7))
 chnum = VAL(MID$(S$, 9, 1))
 diffa = oldchana / 32 - S
```

STEP 5

```
  IF j > 0 THEN PRINT USING "    ###.## uL"; (ABS((rdata(chan, j
- 1, 1) - chana) / 32)) * 50 * 32 / slope(chan);

RETURN

SUB RCV
'***********************RECEIVE DATA FROM METER********************
SCOUNT = (VAL(RIGHT$(TIME$, 2))) + 3
IF SCOUNT > 59 THEN SCOUNT = SCOUNT - 60

A$ = ""
sbuff$ = ""
```

```
DO

 IF LOC(1) > 0 THEN
  ALASTS = A$

STEP 3a
A$ = INPUT$(1, #1)

STEP 3b
  IF NOT (A$ = CR$) THEN sbuff$ = sbuff$ + A$

 END IF

 SCOUNT2 = VAL(RIGHT$(TIME$, 2))
IF SCOUNT = SCOUNT2 THEN
 PRINT
 PRINT "***ERROR*** METER NOT RESPONDING - Check cables and
         power"
 PRINT
 BEEP
 IF RMX THEN CALL sendrmx(14)       'ESCAPE  (HEX 'E")
 SYSTEM
END IF

IF LFFLAG > 0 AND A$ = LF$ THEN A$ = ">"
LOOP WHILE NOT (A$ = ">")

x = LOC(1)
IF x > 256 THEN PRINT "X>256"; x

END SUB

' RFAUTO.Bas => RMX=-1   RFCAL.BAS => RMX=0 RFBENCH.BAS => BENCH=-1
'
'takes .DAT files from PRISM CDS A/D DATA CAPTURE, finds the dispense point
'by looking at point-to-point differences, calculates the mean of the last
'20 points prior to dispense, and stores results in VOL.DAT

'COPYRIGHT ABBOTT LABORATORIES 1994
'AUTHOR:    J Kotlarik
' This version uses a BIOS SW INTERRUPT for machine-independant timing.
' Note: To use CALL INTERRUPT, you must load the Quick library QB.LIB
'       with QuickBASIC. The program also uses the QB.BI header file.
'       If compiling fails to find QB.LIB, use the following commands
'       from the 2nd QB45 (UTILS) disk:  UNPACK QB.LI$ QB.LIB

' Use the following command line when you start QB :

' QB RFAUTO /L QB
```

```
' Include header file for INT86OLD, etc.
'$INCLUDE: 'QB.BI'

DECLARE SUB Delay (counts!)
DECLARE SUB BENCHDISP ()
DECLARE SUB DISPTRAY (chan!)
DECLARE SUB GETREFS (LOWREF$, HIGHREF$)
DECLARE SUB RCV ()
DECLARE SUB sendrmx (rmxsnd)
DECLARE SUB getrmx ()
DECLARE SUB GETNEWKEY (NEWKEY$)
DECLARE SUB TESTREF ()
COMMON SHARED sbuff$
COMMON SHARED CR$
COMMON SHARED LF$
COMMON SHARED ESC$
COMMON SHARED BS$
COMMON SHARED diffa, diffb
COMMON SHARED RMX
COMMON SHARED Raw
COMMON SHARED rmxdatardy
COMMON SHARED rmxrcv
COMMON SHARED LFFLAG
COMMON SHARED NEWKEY$
COMMON SHARED DEBUG
COMMON SHARED READDEL
COMMON SHARED PPORTOUT%
COMMON SHARED PPORTIN%

'Rev$ = "1.0"   '1/19/94 Program creation
'Rev$ = "1.1"   '2/17/94 Added Statistics and auto-linear range detection
'Rev$ = "1.2"   '6/16/94 Interfaced to Eutechnics Meter/Controller
'Rev$ = "1.3"   '8/12/94 Auto-prime and auto-dispense detect
'Rev$ = "1.4"   '10/21/94 RMX and machine id
'Rev$ = "1.5"   '11/3/94 rewrite commRMX and machine id
'Rev$ = "1.6"   '11/22/94 Get from BIOS PP data and status reg address
'Rev$ = "1.7"   '11/29/94 Allow Parallel comm with benchtop fixture
Rev$ = "1.8"    '12/03/94 Save and read slopes from meter

DIM rdata(6, 21, 3)
DIM ref(6, 2, 2)
DIM rarray(21, 4)
DIM slope(6)
DIM PUMPLIST$(10)

CR$ = CHR$(13): ESC$ = CHR$(27)
LF$ = CHR$(10): BS$ = CHR$(8)

DEBUG = 0 'IF DEBUG = -1 THEN ALL TEST DATA DISPLAYED ELSE = 0
```

```
RMX = 0 'IF RMX = 0 THEN PRISM RMX - PC PARALLEL PORT DISABLED -1 -> ENABLED
BENCH = 0 'IF BENCH = 0 THEN PARALLEL COM DISABLED -1 -> ENABLED

VALIDATE = 1
GROUP.SIZE = 20

PUMPLIST$(1) = "MP"
PUMPLIST$(2) = "SD"
PUMPLIST$(3) = "PR"
PUMPLIST$(4) = "PW"
PUMPLIST$(5) = "CO"
PUMPLIST$(6) = "CW"
PUMPLIST$(7) = "AC"
PUMPLIST$(8) = "SA"
PUMPLIST$(9) = "SM"

'*****************GET LPT1 PORT ADDRESS*******************
DEF SEG = &H40
PPORTOUT% = PEEK(&H8) + (PEEK(&H9) * 256)
PPORTIN% = PPORTOUT% + 1
DEF SEG


rerun:

CLS
VIEW PRINT 1 TO 2
IF RMX THEN
 PRINT "              ABBOTT PRISM RF VOLUME VALIDATION REV. ";
ELSE
 PRINT "      ABBOTT PRISM RF VOLUME VALIDATION TRAY CALIBRATION REV. ";
END IF

PRINT Rev$

 PRINT "                Copyright Abbott Laboratories 1994";
 Delay (15000)

slope = 20
SAMPLE = 0
ENDCNT = 6    'number of shots
READDEL = 10500

PRIMESTART = 100      'PRIME START READ-TO-READ DIFFERENCES
PRSTARTCNT = 3 'PRIME START NUMBER OF REPS NEEDED TO STABILIZE

PRIMEDIFF = 1.5    'PRIME SETTLE READ-TO-READ DIFFERENCES
PRIMEREPS = 3   'PRIME SETTLE NUMBER OF REPS NEEDED TO STABILIZE
```

```
DIFF = .9     'NORMAL DISPENSE READ-TO-READ DIFFERENCES
DIFFREPS = 3   'NORMAL DISPENSE NUMBER OF REPS NEEDED TO STABILIZE
'check for a command line parameter containing the filename to process

'******************INITIALIZE   METER   INTERFACE*********************

STEP 1
OPEN "COM1:9600,N,8,1,BIN,CD0,CS0,DS0,RS,TB256,RB32000" FOR RANDOM AS #1'RF
METER SERIAL CONNECTION
CALL Delay(300)

x = INP(&H3FC)  ' set CTS and DTR
x = x OR 3
OUT &H3FC, x

PRINT #1, ESC$;
CALL RCV

ON ERROR GOTO noslope:
FOR i = 1 TO 6
 PRINT #1, "G" + LTRIM$(RTRIM$(STR$(i))) + CR$

STEP 2
 CALL RCV
 TEMP$ = LEFT$(sbuff$, LEN(sbuff$))
 TEMP$ = LTRIM$(RTRIM$(TEMP$))
 slope(i) = VAL(TEMP$)
 IF slope(i) = 0 THEN slope(i) = 5000
 CALL RCV
NEXT

GOTO NOMACHINEID


continueinit:

VIEW PRINT 25 TO 25
PRINT "                    -For Investigational Use Only-";

VIEW PRINT 1 TO 2
LOCATE 2, 1
PRINT SPACE$(79);

IF NOT RMX THEN
 LOCATE 2, 3
 PRINT "PRISM NUMBER " + MACHINEID$ + "   Is this correct? (Y/N or ENTER) >";
 DO
  CALL GETNEWKEY(NEWKEY$)
```

```
LOOP WHILE NEWKEY$ = ""
NEWKEY$ = UCASE$(NEWKEY$)
IF NOT (NEWKEY$ = "Y" OR NEWKEY$ = CR$) THEN GOTO newmachineid
END IF

ON ERROR GOTO errorhandler

IF COMMAND$ <> "" THEN
  L = INSTR(COMMAND$, " ")
  IF L > 0 THEN
        inputfilename$ = LEFT$(COMMAND$, L - 1)
        slope$ = RIGHT$(COMMAND$, LEN(COMMAND$) - L)
        slope = VAL(slope$)
  ELSE
        inputfilename$ = COMMAND$
        slope = 0
  END IF

END IF

'*******************RMX  Parallel  Port  INIT  Start****************
```

STEP 3

```
VIEW PRINT 3 TO 23
LOCATE 4, 1
IF RMX THEN
PRINT "Waiting for PRISM RMX Handshake...";

' init port Set READY high here - low at remote INVERTED SIGNAL BIT 4 OUTPUT
'                                        to BIT 7 INPUT

' SEND 5 THEN A CONTINUOUSLY UNTIL 5 AND A BOTH RECEIVED FROM RMX
' AFTER BOTH 5 AND A RCVD, SENDS 15H THEN 1AH UNTIL READY FROM RMX

RMX5 = 0
RMXA = 0
STATUS = 0

DO

 OUT PPORTOUT%, &H5 OR STATUS
 FOR x = 1 TO 20
  NEWRMX = INP(PPORTIN%)
  STATUSRMX = NEWRMX AND &H80
  NEWRMX = (NEWRMX AND &H78) / 8  'CORRECT FOR DATA SHIFT UP 3 BITS BY LAPLINK
CABLE
  IF NEWRMX = 5 THEN RMX5 = -1
  IF NEWRMX = &HA THEN RMXA = -1
```

```
NEXT

OUT PPORTOUT%, &HA OR STATUS

FOR x = 1 TO 20
 NEWRMX = INP(PPORTIN%)
 STATUSRMX = NEWRMX AND &H80
 NEWRMX = (NEWRMX AND &H78) / 8  'CORRECT FOR DATA SHIFT UP 3 BITS BY LAPLINK
CABLE
 IF NEWRMX = 5 THEN RMX5 = -1
 IF NEWRMX = &HA THEN RMXA = -1
NEXT

IF ((RMX5 <> 0) AND (RMXA <> 0)) THEN STATUSOUT = &H10

LOOP WHILE ((RMX5 = 0) OR (RMXA = 0) OR (STATUSRMX = &H80))

'SEND READY
OUT PPORTOUT%, &H10

' Wait for remote READY (low here - high at remote)
DO
  r = INP(PPORTIN%)
  r = r AND &H80
LOOP WHILE r <> 0      'loop until low

PRINT " Received!";
SLEEP 1

VIEW PRINT 1 TO 2
CLS (2)
LOCATE 1, 1
IF RMX THEN
  PRINT "          ABBOTT PRISM RF VOLUME VALIDATION REV. ";
ELSE
  PRINT "     ABBOTT PRISM RF VOLUME VALIDATION TRAY CALIBRATION REV. ";
END IF

PRINT Rev$;
END IF
'********************RMX   Parallel   Port   INIT   End******************

CALL DISPTRAY(0)

IF NOT RMX THEN
logfilename$ = MACHINEID$ + LEFT$(DATE$, 2) + MID$(DATE$, 4, 2) + "."

 ' Get the run number this setup w/today's date
   count = 1
```

```
 DO
     count$ = LTRIM$(STR$(count))
     IF count < 10 THEN count$ = "0" + count$

     OPEN logfilename$ + "V" + count$ FOR APPEND AS #11

     IF LOF(11) = 0 THEN
             logfilename$ = logfilename$ + "V" + count$
             EXIT DO
     ELSE
             count = count + 1
     END IF

     CLOSE #11
  LOOP UNTIL count > 36
  runnumber = count
 CLOSE #11

VIEW PRINT 1 TO 2
LOCATE 2, 1
PRINT SPACE$(79);

LOCATE 2, 1
PRINT " PRISM " + MACHINEID$ + "              File-" + logfilename$ + "              " +
DATE$;
VIEW PRINT 14 TO 23

'***************************

END IF

'*****************SELECT   WELL   PAIR*****************************
DO
 VIEW PRINT 3 TO 4

 CLS (2)
 PRINT

STEP 4
 IF RMX THEN
 PRINT "           ENTER TEST INFORMATION ON PRISM          ";
 ELSE PRINT "     SELECT WELL PAIR (1)=1,2  (3)=3,4  (5)=5,6  ENTER [1,3,5]>";
 END IF
 x = 0
 DO
 CALL GETNEWKEY(NEWKEY$)

'********************RMX   Parallel   Port   WELL   PAIR   Start****************
```

```
IF RMX THEN

getchan:
 CALL getrmx
 IF rmxrcv <> 6 THEN GOTO getchan'LOOK FOR CHANNEL NUMBER SELECT COMMAND (7)
  DO
   CALL getrmx
    x = rmxrcv          'Get channel number (1-6)
  LOOP WHILE x = 0
   channelnumber = x
   'PRINT "    Channel "; channelnumber

getpumpno:
 CALL getrmx
 IF rmxrcv <> 7 THEN GOTO getpumpno 'LOOK FOR PUMP NUMBER SELECT COMMAND (6)

  DO
   CALL getrmx
    x = rmxrcv          'Get pump number (1-9)
  LOOP WHILE x = 0
  PUMPNUMBER = x
   'PRINT "    Pump # "; pumpnumber

getprid:
 CALL getrmx
 IF rmxrcv <> 8 THEN GOTO getprid 'LOOK FOR PRISM UNIT ID NUMBER COMMAND (8)
  DO
   CALL getrmx
    x = rmxrcv          'Get PRISM Unit ID number digit 1 of 3 (0-9)
   LOOP WHILE (rmxdatardy = 0)
   prismno1 = x

  DO
   CALL getrmx
    x = rmxrcv          'Get PRISM Unit ID number digit 2 of 3 (0-9)
   LOOP WHILE (rmxdatardy = 0)
   prismno2 = x

  DO
   CALL getrmx
    x = rmxrcv          'Get PRISM Unit ID number digit 3 of 3 (0-9)
   LOOP WHILE (rmxdatardy = 0)
   prismno3 = x

    IF prismno3 = 10 THEN prismno3$ = "" ELSE prismno3$ = STR$(prismno3)
    IF prismno2 = 10 THEN prismno2$ = "" ELSE prismno2$ = STR$(prismno2)
    IF prismno1 = 10 THEN prismno1$ = "" ELSE prismno1$ = STR$(prismno1)

     prismid$ = LTRIM$(prismno1$) + LTRIM$(prismno2$) + LTRIM$(prismno3$)
```

```
idcnt = LEN(prismid$)
IF idcnt = 1 THEN prismid$ = "00" + prismid$
IF idcnt = 2 THEN prismid$ = "0" + prismid$

prismid = VAL(prismid$)
'PRINT "   PRISM " + prismid$
MACHINEID$ = prismid$

'''''''''''''''''''''''''''
'create filename for this run

logfilename$ = MACHINEID$ + LTRIM$(STR$(channelnumber)) + LEFT$(DATE$, 2) + MID$(DATE$, 4, 2) + "."

' Get the run number this setup w/today's date
  count = 1

 DO
     count$ = LTRIM$(STR$(count))
     IF count > 9 THEN count$ = asc$(count + &H31)  'count >9 -> "A-Z"

     OPEN logfilename$ + PUMPLIST$(PUMPNUMBER) + count$ FOR APPEND AS #11

     IF LOF(11) = 0 THEN
          logfilename$ = logfilename$ + PUMPLIST$(PUMPNUMBER) + count$
          EXIT DO
     ELSE
          count = count + 1
     END IF

     CLOSE #11
 LOOP UNTIL count > 36
 runnumber = count
CLOSE #11


VIEW PRINT 1 TO 2
LOCATE 2, 1
PRINT SPACE$(79);

LOCATE 2, 1
PRINT " PRISM " + MACHINEID$ + "     File-" + logfilename$ + "     Channel ";
channelnumber; "    " + PUMPLIST$(PUMPNUMBER) + " Pump     " + DATE$;
VIEW PRINT 14 TO 23

'''''''''''''''''''''''''''

getcupno:
```

```
x = 0
CALL getrmx
IF rmxrcv <> 1 THEN GOTO getcupno 'LOOK FOR well-pair SELECT COMMAND (1)
 DO
  CALL getrmx
   x = rmxrcv          'Get well pair (1,3,5)
 LOOP WHILE x = 0
  cupnumber = x

END IF
'*******************RMX Parallel Port WELL PAIR End****************


 LOOP WHILE (NEWKEY$ = "") AND (x = 0)
 IF x = 0 THEN x = VAL(NEWKEY$)

LOOP WHILE NOT (x = 1 OR x = 3 OR x = 5)

'**********************

VIEW PRINT 14 TO 23
chan = x
chana$ = asc$(x)
chanb$ = asc$(x + 1)
'*****************START OF CHANNEL DATA COLLECTION*************
PRINT #1, ESC$;
CALL RCV

chana$ = LTRIM$(STR$(chan))
chanb$ = LTRIM$(STR$(chan + 1))
stub$ = "D+ " + chana$ + " " + chanb$

PRINT #1, stub$ + CR$
CALL RCV

'*****************TRAY STABILITY CHECK**********

CALL TESTREF

'*************************************************

VIEW PRINT 4 TO 5
CLS (2)
PRINT
IF (RMX OR BENCH) THEN
 PRINT "                    WAIT FOR PRISM TO PRIME WELLS                    "
ELSE
 PRINT "  FILL CUPS " + chana$ + " and " + chanb$ + " WITH 350 uL FLUID THEN WAIT
FOR BEEP WHILE READS STABILIZE";
 BEEP
END IF
```

Patent document cited in search report	Publication date	Patent family member(s)		Publication date
EP-A-0338400	25-10-89	DE-A-	3812687	26-10-89
		DE-D-	58908161	15-09-94
US-A-4107993	22-08-78	NONE		
US-A-5275951	04-01-94	AU-B-	2193492	12-01-93
		AU-B-	2250892	12-01-93
		AU-B-	2257592	12-01-93
		AU-B-	2259592	12-01-93
		AU-B-	2266892	12-01-93
		CA-A-	2109944	23-12-92
		EP-A-	0588931	30-03-94
		EP-A-	0588967	30-03-94
		EP-A-	0588968	30-03-94
		EP-A-	0588969	30-03-94
		EP-A-	0588972	30-03-94
		JP-T-	6507495	25-08-94
		JP-T-	6507496	25-08-94
		JP-T-	6507497	25-08-94
		JP-T-	6507498	25-08-94
		JP-T-	6507499	25-08-94
		WO-A-	9222800	23-12-92
		WO-A-	9222879	23-12-92
		WO-A-	9222801	23-12-92
		WO-A-	9222802	23-12-92
		WO-A-	9222880	23-12-92
EP-A-0426622	08-05-91	NONE		
US-A-5351036	27-09-94	CA-A-	2124695	24-06-93
		EP-A-	0616687	28-09-94
		JP-T-	7504977	01-06-95
		WO-A-	9312408	24-06-93

International Application No
PCT/US 96/00611

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP,A,0 426 622 (ITAL IDEE SRL) 8 May 1991 see column 3, line 10 - line 40 see column 5, line 10 - line 25; claim 1; figure 3 ---	1-12
A	US,A,5 351 036 (BROWN DAVID P ET AL) 27 September 1994 see column 11, line 40 - column 12, line 35; claims 1,32; figures 2,3,7 ---	1-12
A	PATENT ABSTRACTS OF JAPAN vol. 010, no. 252 (C-369), 29 August 1986 & JP,A,61 078458 (SHIMADZU CORP), 22 April 1986, see the whole document -----	1-12

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INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 96/00611

A. CLASSIFICATION OF [illegible]ECT MATTER
IPC 6 G01F23/[illegible]

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 G01F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP,A,0 338 400 (DUERRWAECHTER E DR DODUCO) 25 October 1989 see page 2, line 23 - page 3, line 6; claim 1; figure 1 ---	1-12
X	US,A,4 107 993 (SHUFF THOMAS J ET AL) 22 August 1978 see column 2, line 15 - column 3, line 22 see column 4, line 57-69; figures 1,2 ---	1-12
A	US,A,5 275 951 (CHOW HERBERT S ET AL) 4 January 1994 see column 3, line 40-45 see column 6, line 40 - column 7, line 20; claim 1; figure 7 ---	1-12
	-/--	

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

* Special categories of cited documents :

- 'A' document defining the general state of the art which is not considered to be of particular relevance
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- 'Y' document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- '&' document member of the same patent family

1

Date of the actual completion of the international search	Date of mailing of the international search report
22 May 1996	2 0. 06. 96

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+ 31-70) 340-2040, Tx. 31 651 epo nl, Fax (+ 31-70) 340-3016	Mason, W

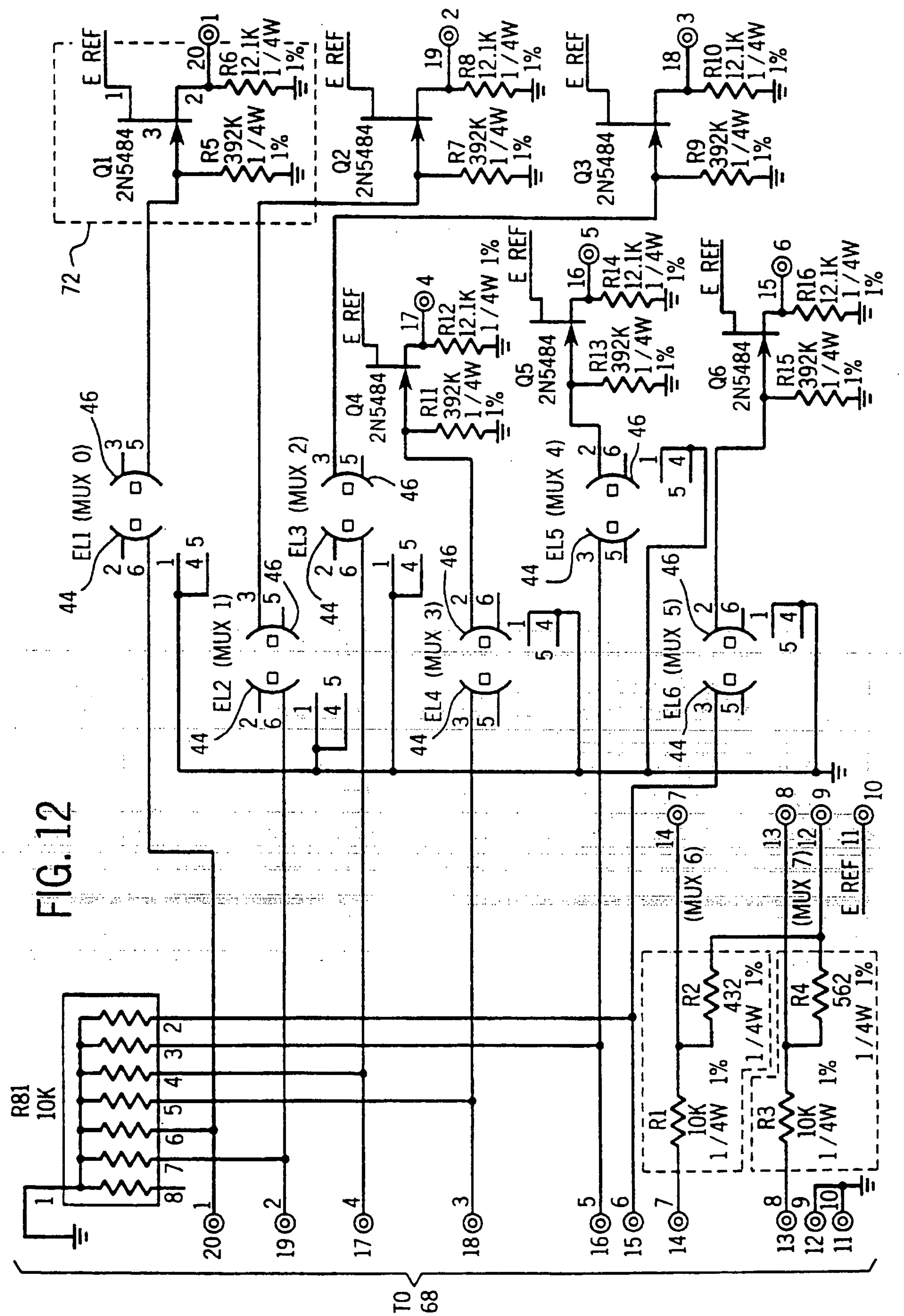

E REF
Q1
2N5484
Q2
2N5484
Q3
2N5484
Q4
2N5484
Q5
2N5484
Q6
2N5484
R5 392K 1/4W 1%
R6 12.1K 1/4W 1%
R7 392K 1/4W 1%
R8 12.1K 1/4W 1%
R9 392K 1/4W 1%
R10 12.1K 1/4W 1%
R11 392K 1/4W 1%
R12 12.1K 1/4W 1%
R13 392K 1/4W 1%
R14 12.1K 1/4W 1%
R15 392K 1/4W 1%
R16 12.1K 1/4W 1%
72
EL1 (MUX 0)
EL2 (MUX 1)
EL3 (MUX 2)
EL4 (MUX 3)
EL5 (MUX 4)
EL6 (MUX 5)
(MUX 6)
(MUX 7)
E REF
R1 10K 1/4W 1%
R2 432 1/4W 1%
R3 10K 1/4W 1%
R4 562 1/4W 1%
R81
10K
TO
68

FIG. 12

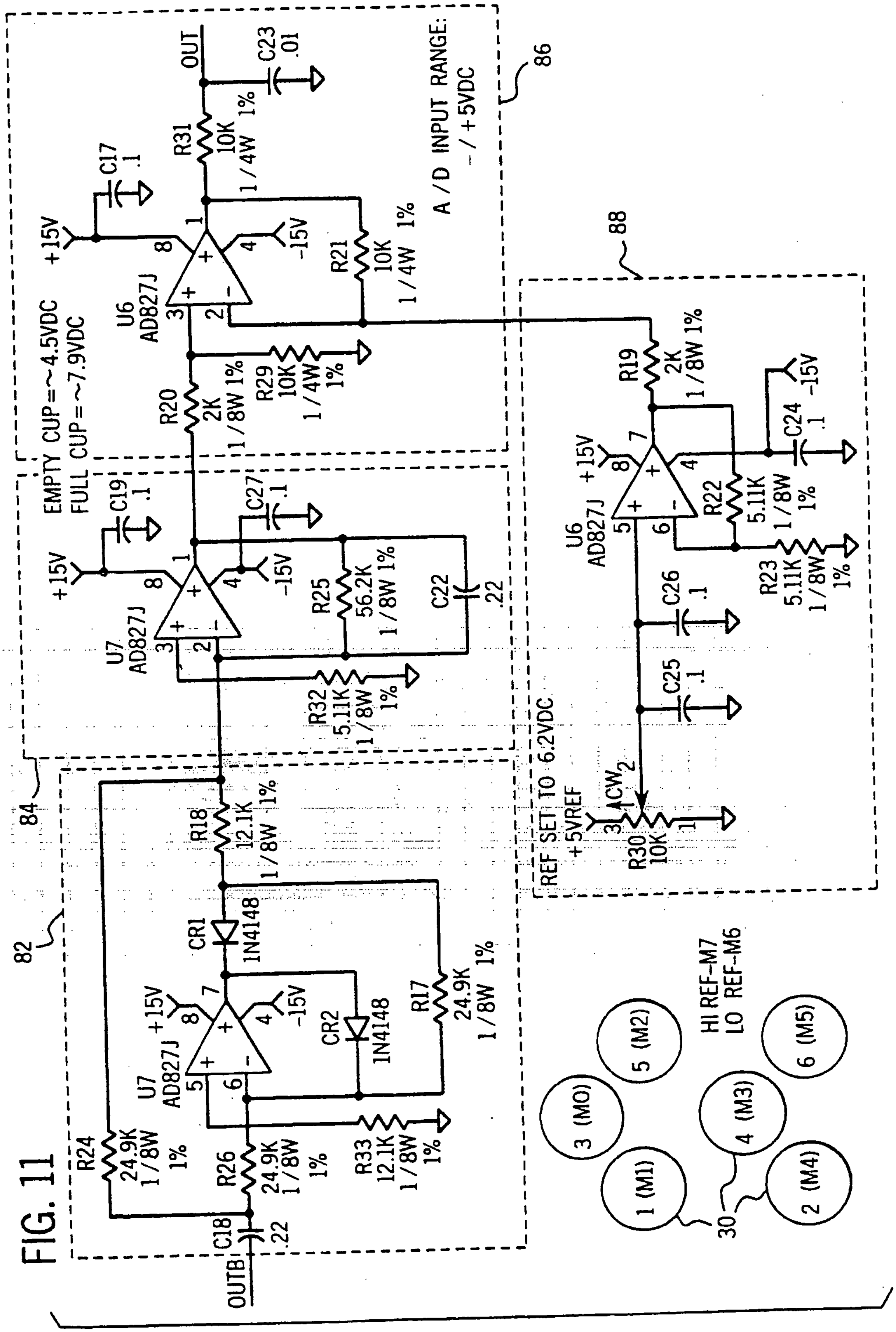

OUT
C23
.01
R31
10K
1/4W 1%
C17
.1
+15V
-15V
U6
AD827J
R21
10K
1/4W 1%
A/D INPUT RANGE:
-/+5VDC
86
EMPTY CUP=~4.5VDC
FULL CUP=~7.9VDC
R20
2K
1/8W 1%
R29
10K
1/4W
1%
88
R19
2K
1/8W 1%
C24
.1
R22
5.11K
1/8W
1%
R23
5.11K
1/8W
1%
C19
.1
C27
.1
U7
AD827J
R25
56.2K
1/8W 1%
C22
.22
R32
5.11K
1/8W
1%
C26
.1
C25
.1
REF SET TO 6.2VDC
+5VREF
ACW
R30
10K
84
82
R18
12.1K
1/8W 1%
CR1
1N4148
CR2
1N4148
R17
24.9K
1/8W 1%
R24
24.9K
1/8W
1%
R26
24.9K
1/8W
1%
R33
12.1K
1/8W
1%
C18
.22
OUTB
HI REF-M7
LO REF-M6
3 (M0)
5 (M2)
1 (M1)
4 (M3)
6 (M5)
2 (M4)
30

FIG. 11

6 /8

FIG. 10

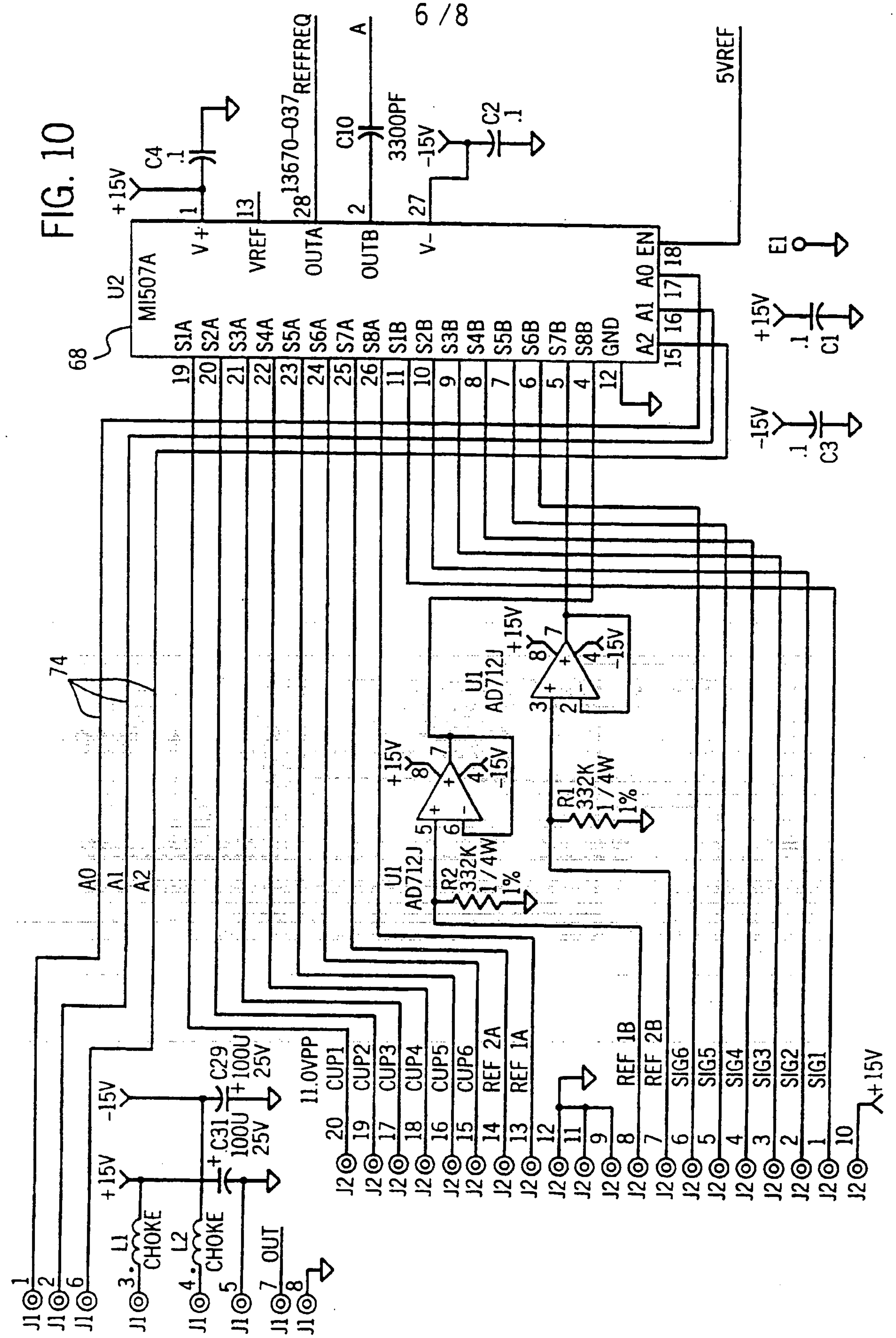
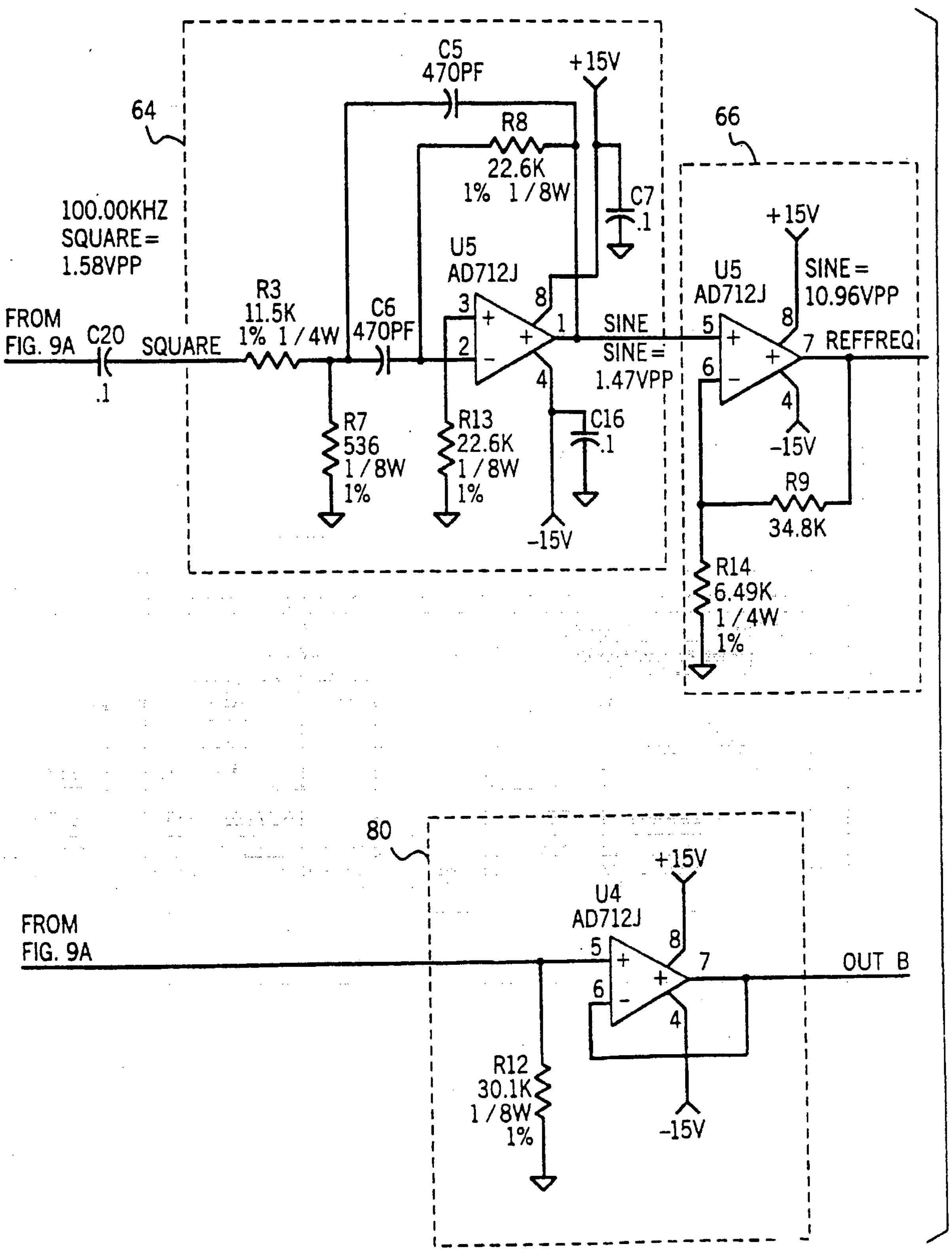
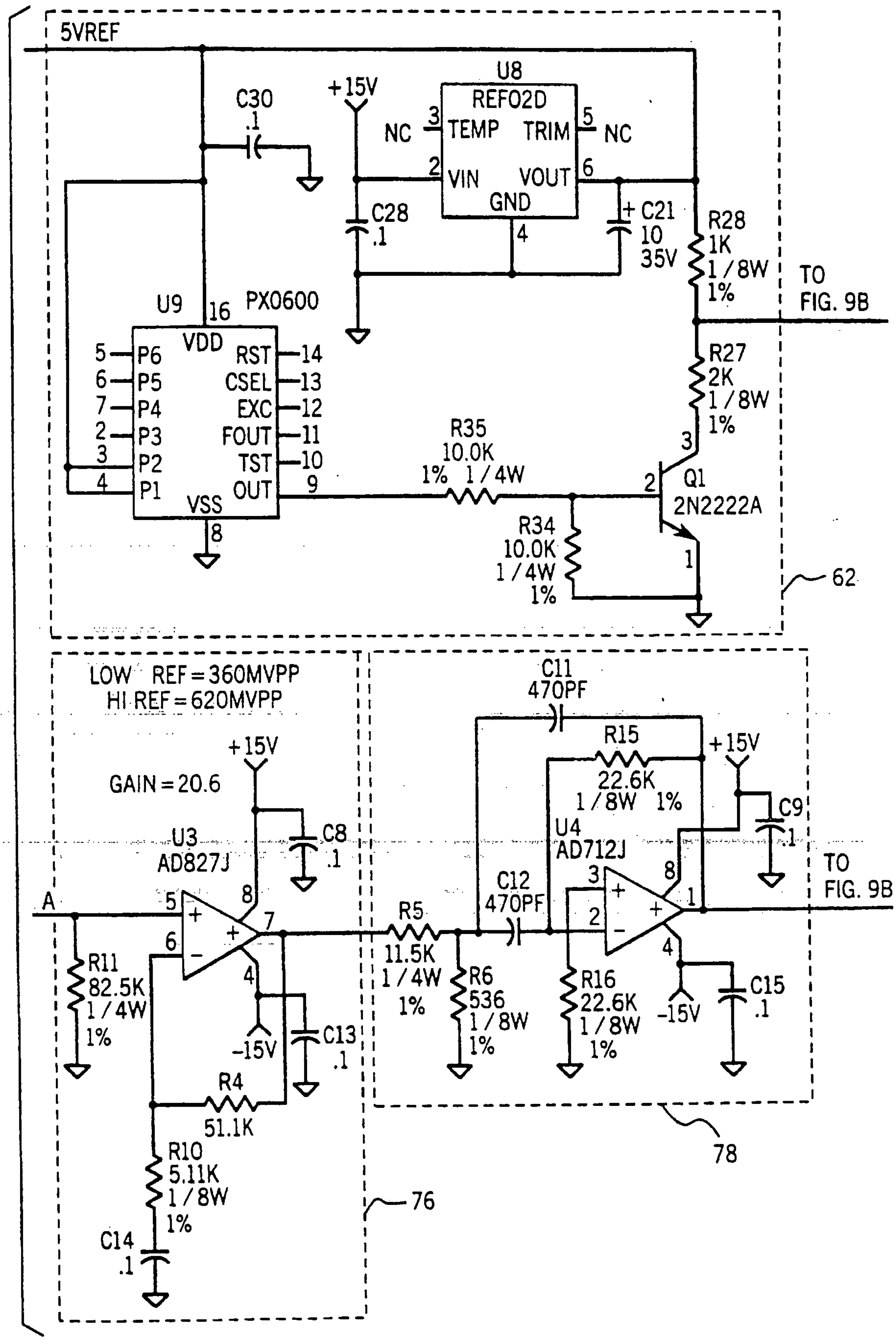

U2
MI507A
68
74
U1
AD712J
R1
332K
1/4W
1%
R2
332K
1/4W
1%
C4
C10
3300PF
C2
C1
C3
C29
C31
100U
25V
13670-037
REFFREQ
5VREF
E1
L1
L2
CHOKE
OUT
A0
A1
A2
11.0VPP
CUP1
CUP2
CUP3
CUP4
CUP5
CUP6
REF 2A
REF 1A
REF 1B
REF 2B
SIG6
SIG5
SIG4
SIG3
SIG2
SIG1
J1
J2
+15V
-15V

FIG. 9B



64
FROM FIG. 9A
C20
.1
SQUARE
100.00KHZ SQUARE= 1.58VPP
R3 11.5K 1% 1/4W
C5 470PF
R8 22.6K 1% 1/8W
C6 470PF
+15V
C7 .1
U5 AD712J
R7 536 1/8W 1%
R13 22.6K 1/8W 1%
C16 .1
-15V
SINE
SINE= 1.47VPP
66
U5 AD712J
SINE= 10.96VPP
REFFREQ
R9 34.8K
R14 6.49K 1/4W 1%
80
FROM FIG. 9A
U4 AD712J
R12 30.1K 1/8W 1%
OUT B

FIG. 9A



5VREF
C30
.1
+15V
U8
REF02D
NC
3 TEMP
TRIM 5
NC
2 VIN
VOUT 6
GND
4
C28
.1
+ C21
10
35V
R28
1K
1/8W
1%
TO
FIG. 9B
U9
16
PX0600
VDD
5 P6
6 P5
7 P4
2 P3
3 P2
4 P1
RST 14
CSEL 13
EXC 12
FOUT 11
TST 10
OUT 9
VSS
8
R27
2K
1/8W
1%
R35
10.0K
1% 1/4W
3
2
Q1
2N2222A
1
R34
10.0K
1/4W
1%
62
LOW REF=360MVPP
HI REF=620MVPP
GAIN=20.6
+15V
U3
AD827J
C8
.1
A
5
6
8
7
4
R11
82.5K
1/4W
1%
-15V
C13
.1
R4
51.1K
R10
5.11K
1/8W
1%
C14
.1
76
C11
470PF
R15
22.6K
1/8W 1%
+15V
C9
.1
U4
AD712J
3
2
8
1
4
C12
470PF
R5
11.5K
1/4W
1%
R6
536
1/8W
1%
R16
22.6K
1/8W
1%
-15V
C15
.1
TO
FIG. 9B
78

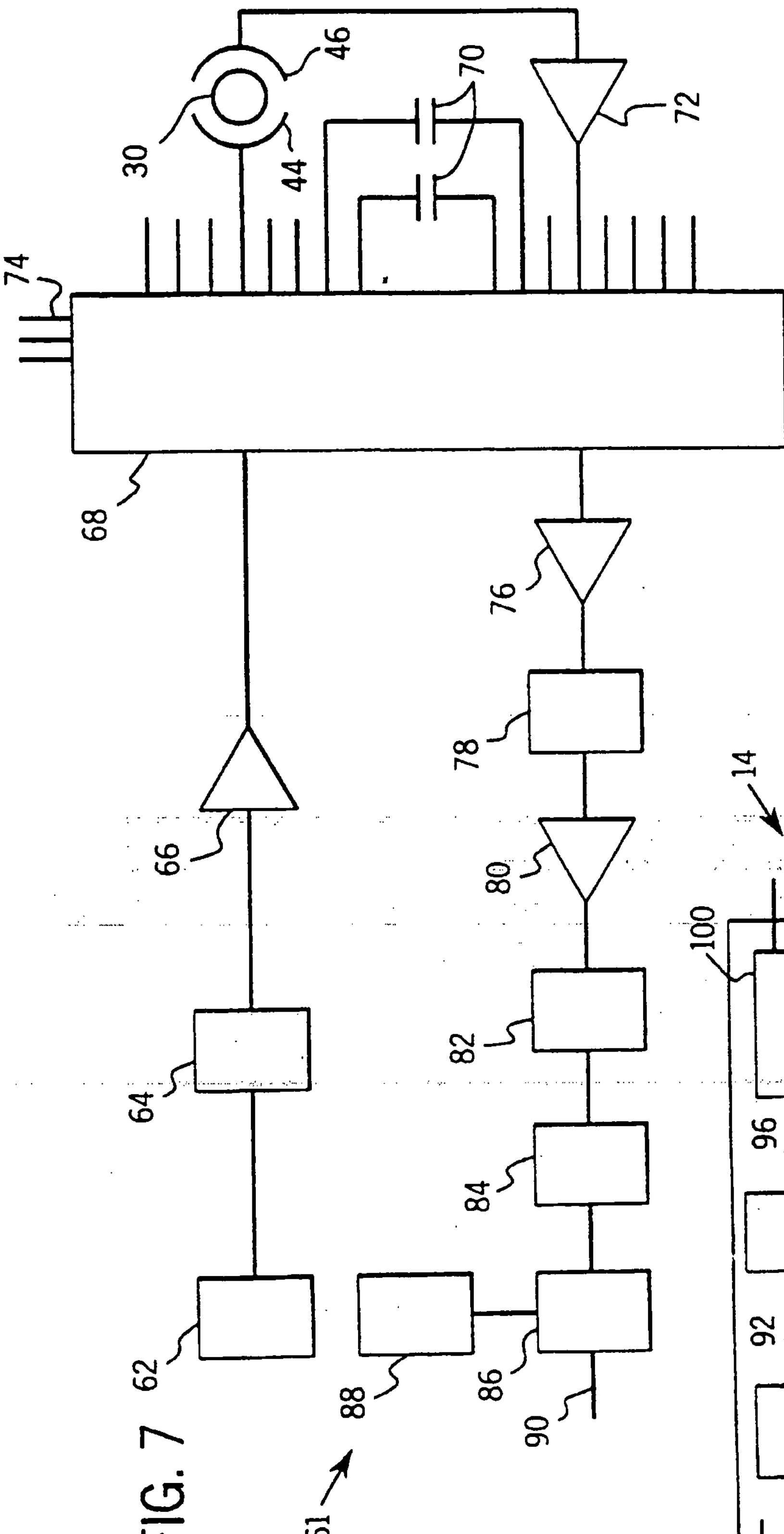

74
30
46
44
70
72
68
66
64
62
76
78
80
82
84
86
88
90
61

FIG. 7

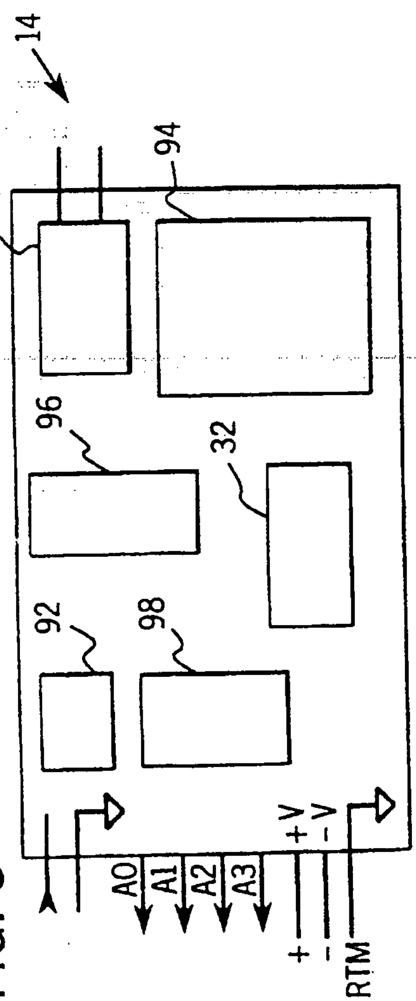

14
100
94
96
32
92
98
A0
A1
A2
A3
+V
-V
+
-
RTM

FIG. 8

FIG. 4

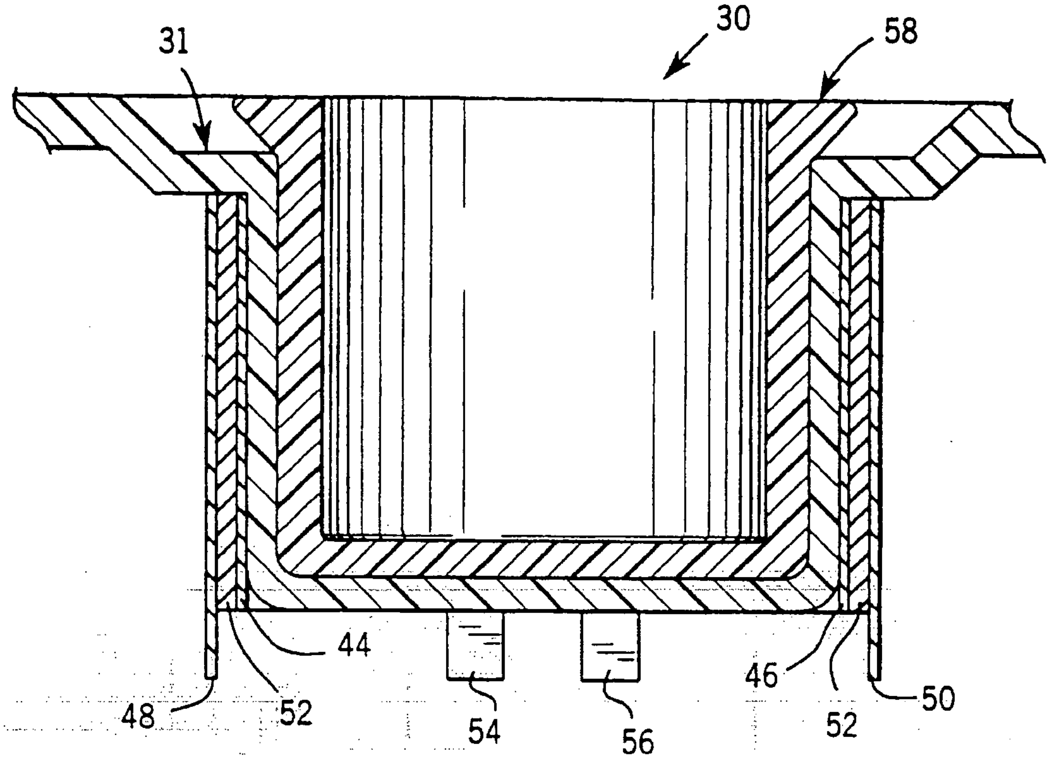


FIG. 5

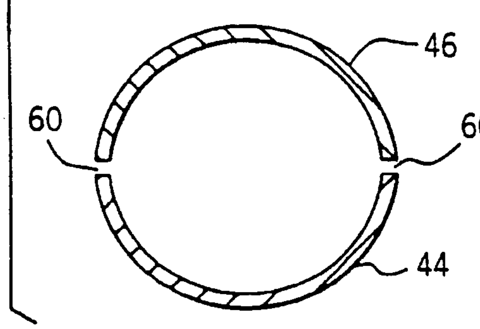


FIG. 6

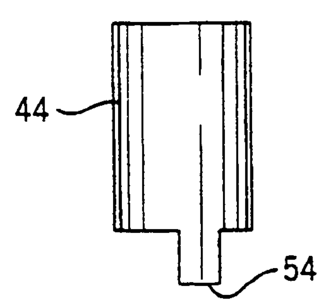


FIG. 1

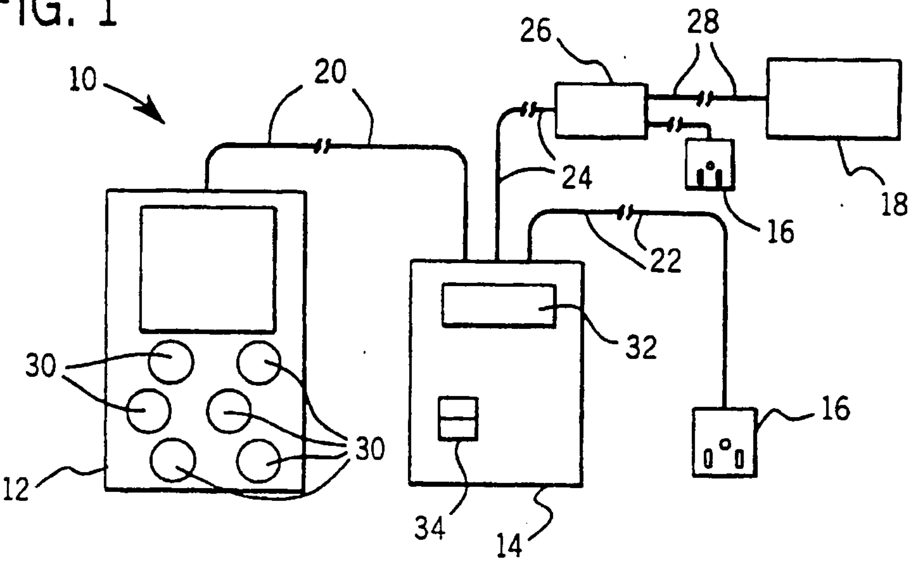


FIG. 2

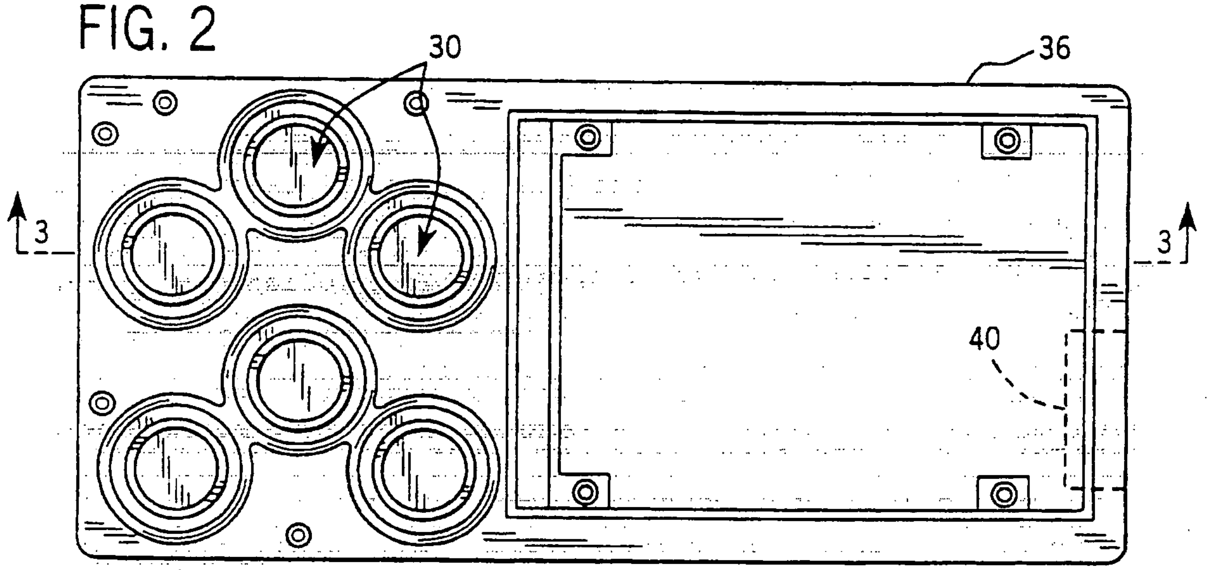
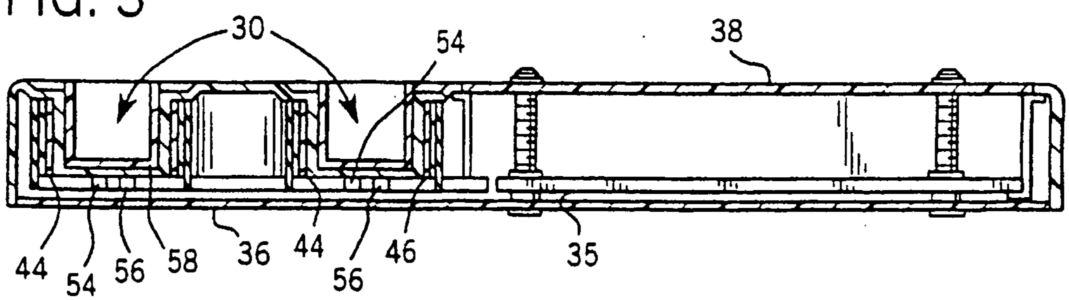


FIG. 3



11. A method for verifying a volume of a fluid, the method comprising the steps of:

(a) placing a volume of fluid within a receptacle;

(b) positioning a first conductor adjacent the receptacle such that the first conductor does not contact the volume of fluid;

(c) positioning a second conductor adjacent the receptacle such that the second conductor does not contact the volume of fluid or the first conductor;

(d) applying a first electrical signal to the first conductor; and

(e) monitoring a second electrical signal generated in the second conductor responsive to the first electrical signal to verify the volume of the fluid in the receptacle.

12. An apparatus for verifying a volume of fluid comprising:

(a) a receptacle for containing fluid;

(b) a first conductor operatively associated with the receptacle such that the first conductor does not contact the volume of the fluid;

(c) a second conductor operatively associated with the receptacle offset from the first conductor such that the first conductor does not contact the volume of the fluid;

(d) a source of a first electrical signal electrically connected with the first conductor; and

(e) a monitor electrically connected with the second conductor for detecting a second electrical signal created in the second conductor.

6. An apparatus as defined in claim 1 further comprising:
(f) a liner removably connectable with the receptacle.

7. An apparatus as defined in claim 1 further comprising:
(f) a computer electrically connected with at least one of the first conductor and the second conductor.

8. A method for verifying a volume of fluid dispensed from a nozzle, the method comprising the steps of:
(a) positioning a receptacle adjacent the nozzle such that fluid dispensed from the nozzle enters the receptacle;
(b) applying a first electrical signal to a first conductor operatively connected with the receptacle; and
(c) monitoring a second electrical signal created in a second conductor operatively connected with the receptacle responsive to the first electrical signal.

9. A method as defined in claim 8 further comprising the steps of:
(d) predetermining a condition indicative of a desired volume of fluid; and
(e) comparing the second electrical signal with the condition to determine if the desired volume of fluid were in the receptacle.

10. A method as defined in claim 8 wherein the monitoring step (c) comprises
i. monitoring at least one of an amplitude of and a voltage associated with the second electrical signal.

WHAT IS CLAIMED IS:

1. An apparatus for verifying a volume of fluid comprising:

(a) a receptacle for containing fluid;

(b) a first conductor operatively associated with the receptacle;

(c) a second conductor operatively associated with the receptacle offset from the first conductor;

(d) a source of a first electrical signal electrically connected with the first conductor; and

(e) a monitor electrically connected with the second conductor for detecting a second electrical signal created in the second conductor.

2. An apparatus as defined in claim 1 further comprising:

(f) a feedback mechanism operatively connected with the monitor such that the feedback mechanism provides feedback indicative of the second electrical signal.

3. An apparatus as defined in claim 1 further comprising:

(f) a third conductor electrically connected with at least one of the first conductor and the second conductor to electromagnetically shield the at least one of the first conductor and the second conductor.

4. An apparatus as defined in claim 3 further comprising:

(g) an electrical insulator electrically disposed between the third conductor and the at least one of the first conductor and the second conductor.

5. An apparatus as defined in claim 1 further comprising:

(f) a liner connectable with the receptacle.

```
CALL RCV
CALL GETNEWKEY(NEWKEY$)

IF DEBUG THEN PRINT sbuff$;
 SCOUNT2 = VAL(RIGHT$(TIME$, 2))
LOOP WHILE SCOUNT2 < SCOUNTEND

LFFLAG = 0

ENDREF = VAL((LEFT$(sbuff$, 7)))

DIFFREF = ABS((ENDREF - STARTREF))
IF DIFFREF < 15 THEN '15  FOR 5 SEC = 180 CNTS/MIN MAX DRIFT
  PRINT #1, ESC$;
  CALL RCV
  CLS (2)
  EXIT SUB
END IF

PRINT #1, ESC$;
CALL RCV

PRINT
PRINT "RETRY #"; Z; "  OF  "; NUMTRIES; " START CNT -"; STARTREF; "  END CNT -";
ENDREF
NEXT Z

'FAILURE TO STABILIZE
PRINT
PRINT "***ERROR*** METER NOT STABILIZING WITHIN 1 MINUTE "
PRINT "           Allow 10 minutes for tray warmup and check tray and cups."
PRINT
BEEP
IF RMX THEN CALL sendrmx(14)      'ESCAPE  (HEX 'E")

SYSTEM

END SUB
```

```
LOOP WHILE (S AND &H80) > 0 'lo here - hi at remote

END SUB

SUB TESTREF
'*GET    LOW    REFERENCE********************************
VIEW PRINT 4 TO 5
CLS (2)
PRINT "                WAIT FOR TRAY STABILITY TEST ...";

PRINT #1, ESC$;
CALL RCV

PRINT #1, "M6"
CALL RCV

CALL Delay(READDEL)

NUMTRIES = 200

FOR Z = 1 TO NUMTRIES

 SCOUNT = (VAL(RIGHT$(TIME$, 2))) + 1
 IF SCOUNT > 59 THEN SCOUNT = SCOUNT - 60
 SCOUNTEND = SCOUNT + 6
 IF SCOUNTEND > 59 THEN SCOUNTEND = SCOUNTEND - 60

'SYNC TO NEXT SECOND
DO
  SCOUNT2 = VAL(RIGHT$(TIME$, 2))
 LOOP WHILE SCOUNT2 = SCOUNT


 VIEW PRINT 14 TO 23
 LOCATE 23, 1

 PRINT #1, "C"

 LFFLAG = 1

DO
 CALL RCV
 CALL GETNEWKEY(NEWKEY$)
  STARTREF = VAL((LEFT$(sbuff$, 7)))
LOOP WHILE STARTREF = 0


DO
```

```
 IF NOT (A$ = CR$) THEN sbuff$ = sbuff$ + A$
' scount = 0

'ELSE
' scount = scount + 1

END IF


 SCOUNT2 = VAL(RIGHT$(TIME$, 2))
IF SCOUNT = SCOUNT2 THEN
 PRINT
 PRINT "****ERROR*** METER NOT RESPONDING - Check cables and power"
 PRINT
 BEEP
 IF RMX THEN CALL sendrmx(14)      'ESCAPE  (HEX 'E")
 SYSTEM
END IF


'IF scount > 100 THEN EXIT DO
IF LFFLAG > 0 AND A$ = LF$ THEN A$ = ">"
LOOP WHILE NOT (A$ = ">")

x = LOC(1)
IF x > 256 THEN PRINT "X>256"; x

END SUB

SUB sendrmx (rmxsnd)
 x = rmxsnd
 OUT PPORTOUT%, (x OR &H10)    'set data
 OUT PPORTOUT%, x              'set READY ( low here - high at remote)

 IF x = 14 THEN EXIT SUB

 DO
  S = INP(PPORTIN%)
 LOOP WHILE (S AND &H80) = 0   'wait for ACK & echo (hi here - lo at remote)

 OUT PPORTOUT%, &H10           'reset ready - hi here - lo at remote

   cchar = ((S AND &H78) / 8)
  IF DEBUG THEN PRINT "SENT TO RMX - "; cchar        ' print echo'ed char


 DO
  S = INP(PPORTIN%)           ' wait for ack to reset
```

```
END SUB

SUB getrmx
rmxdatardy = 0
rmxrcv = 0  'clear last char
S = INP(PPORTIN%)  'look for READY from remote

IF (S AND &H80) > 0 THEN     'high here -low at remote
    cchar = ((S AND &H78) / 8)  ' mask strobe and shift right 3x
   IF DEBUG THEN PRINT "RCVD FROM RMX - "; cchar
   x = cchar
  GOSUB ackch
    rmxdatardy = -1
END IF

rmxrcv = cchar
EXIT SUB

ackch:
 OUT PPORTOUT%, (x OR &H10)
 OUT PPORTOUT%, x

DO
 GETNEWKEY (NEWKEY$)
  S = INP(PPORTIN%)
LOOP WHILE (S AND &H80) > 0

OUT PPORTOUT%, &H10
RETURN

END SUB

SUB RCV
'********************RECEIVE DATA FROM METER********************
SCOUNT = (VAL(RIGHT$(TIME$, 2))) + 3
IF SCOUNT > 59 THEN SCOUNT = SCOUNT - 60

A$ = ""
sbuff$ = ""

DO

IF LOC(1) > 0 THEN
 ALAST$ = A$
  A$ = INPUT$(1, #1)

' PRINT a$;
' PRINT VAL(A$);
' IF ((ECHO$ = (CR$)) AND A$ = CHR$(6)) THEN SBUFF$ = SBUFF$ + CR$: EXIT DO
```

```
PRINT "        WAIT WHILE LOW REFERENCE READS ARE OBTAINED";

PRINT #1, ESC$;
CALL RCV

PRINT #1, "M6"
CALL RCV

VIEW PRINT 14 TO 23
LOCATE 23, 1
PRINT #1, "C"

LFFLAG = 1
CALL RCV

FOR i = 1 TO 5
 CALL RCV
 IF (i > 1) AND DEBUG THEN PRINT sbuff$;
NEXT

LFFLAG = 0

LOWREF$ = LEFT$(sbuff$, 7)

'*GET   HIGH   REFERENCE*********************************
VIEW PRINT 3 TO 4
CLS (2)
PRINT
PRINT "        WAIT WHILE HIGH REFERENCE READS ARE OBTAINED";

PRINT #1, ESC$;
CALL RCV

PRINT #1, "M7"
CALL RCV

VIEW PRINT 14 TO 23
LOCATE 23, 1
PRINT #1, "C"
LFFLAG = 1
CALL RCV


FOR i = 1 TO 5
 CALL RCV
 IF (i > 1) AND DEBUG THEN PRINT sbuff$;
NEXT
HIGHREF$ = LEFT$(sbuff$, 7)
LFFLAG = 0
```

```
CASE 4
PRINT "          |  X         |"
PRINT "          |X   X       |"
PRINT "          |  3         |"
PRINT "          |X   X       |"

CASE 5
PRINT "          |  X         |"
PRINT "        B |X   6       |"
PRINT "          |  X         |"
PRINT "        A |X   5       |"

CASE 6
PRINT "          |  X         |"
PRINT "          |X   X       |"
PRINT "          |  X         |"
PRINT "          |X   5       |"

END SELECT
PRINT "                    -----------------------"
PRINT
IF DEBUG THEN
PRINT " RAW-A MX  ADJ-A  LAST RD  VOLUME    RAW-B MX  ADJ-B  LAST RD
VOLUME";
ELSE
PRINT " Dispense No.    Sub-A     Sub-B"
END IF
END SUB

SUB GETNEWKEY (NEWKEY$)
 NEWKEY$ = UCASE$(INKEY$)
 IF NEWKEY$ = ESC$ THEN
  CLS
  PRINT
  PRINT "RUN ABORTED BY USER"
'********************RMX   Parallel   ****************
  IF RMX THEN
   CALL sendrmx(14)      'ESCAPE  (HEX 'E")
  END IF
'********************RMX   Parallel   ****************
  SYSTEM
 END IF
END SUB

SUB GETREFS (LOWREF$, HIGHREF$)
''GET   LOW   REFERENCE*********************************
VIEW PRINT 3 TO 4
CLS (2)
PRINT
```

```
DIM INARY%(7), OUTARY%(7)          'Define input and output
                                   'arrays for INT86.
'
' Define register-array indices to
' make program easier to understand.
CONST ax = 0, bx = 1, cx = 2, dx = 3, bp = 4, si = 5, di = 6, FL = 7
'

INARY%(ax) = &H8600            'DOS function to WAIT SERVICE
INARY%(cx) = counts / 800        'DOS HIGH ORDER WAIT
INARY%(dx) = &H61A8            'DOS LOW ORDER WAIT
x = INP(&H61)

CALL INT86OLD(&H15, INARY%(), OUTARY%())
                               'Perform the delay
'
END SUB

SUB DISPTRAY (chan)
VIEW PRINT 5 TO 14
CLS (2)
PRINT
PRINT "                            -------------------------"
SELECT CASE chan

CASE 0
PRINT "           |  4            |"
PRINT "         B |2    6         |"
PRINT "           |  3            |"
PRINT "         A |1    5         |"

CASE 1
PRINT "           |  X            |"
PRINT "         B |2    X         |"
PRINT "           |  X            |"
PRINT "         A |1    X         |"

CASE 2
PRINT "           |  X            |"
PRINT "           |X    X         |"
PRINT "           |  X            |"
PRINT "           |1    X         |"

CASE 3
PRINT "         B |  4            |"
PRINT "           |X    X         |"
PRINT "         A |  3            |"
PRINT "           |X    X         |"
```

```
idcnt = idcnt - 1
LOCATE CSRLIN, (POS(0) - 1)
PRINT " ";

LOCATE CSRLIN, (POS(0) - 1)
NEWSLOPE$ = LEFT$(NEWSLOPE$, (LEN(NEWSLOPE$) - 1))
END IF

ELSE
IF idcnt = 5 THEN
idcnt = idcnt - 1
LOCATE CSRLIN, (POS(0) - 1)
NEWSLOPE$ = LEFT$(NEWSLOPE$, (LEN(NEWSLOPE$) - 1))
END IF

NEWSLOPE$ = NEWSLOPE$ + NEWKEY$
idcnt = idcnt + 1
PRINT NEWKEY$;
END IF

LOOP WHILE idcnt < 6

SLOPEVAL = VAL(NEWSLOPE$)
LOCATE CSRLIN, 1
PRINT SPACE$(79);
LOCATE CSRLIN, 1
RETURN

SUB BENCHDISP

REM Start Pump by writing 1H to Parallel Port
OUT PPORTOUT%, &H1
WAIT PPORTIN%, &H20, &H20
WAIT PPORTIN%, &H20
REM Wait for 300ms
CALL Delay(3300)
OUT PPORTOUT%, &H0
REM Stop Pump by writing 0H to Parallel Port
OUT PPORTOUT%, &H0

END SUB

SUB Delay (counts)
'x = 0
'WHILE x < counts
'x = x + 1

'WEND
```

```
   idcnt = 4
  EXIT DO
 END IF

 IF NEWKEY$ = BS$ THEN
  IF idcnt > 0 THEN
   idcnt = idcnt - 1
   LOCATE CSRLIN, (POS(0) - 1)
   PRINT " ";

   LOCATE CSRLIN, (POS(0) - 1)
   MACHINEID$ = LEFT$(MACHINEID$, (LEN(MACHINEID$) - 1))
  END IF

 ELSE
  IF idcnt = 3 THEN
   idcnt = idcnt - 1
   LOCATE CSRLIN, (POS(0) - 1)
   MACHINEID$ = LEFT$(MACHINEID$, (LEN(MACHINEID$) - 1))
  END IF

  MACHINEID$ = MACHINEID$ + NEWKEY$
  idcnt = idcnt + 1
 PRINT NEWKEY$;
 END IF

LOOP WHILE idcnt < 5
RETURN

'GETMACHINEID:

GETSLOPE:
NEWSLOPE$ = ""
idcnt = 0
PRINT
PRINT "ENTER CORRECT VALUE FOR THIS WELL IN uL (xx.xx) > ";
DO
 DO
  CALL GETNEWKEY(NEWKEY$)
 LOOP WHILE NEWKEY$ = ""

 IF NEWKEY$ = CR$ THEN
  IF idcnt < 2 THEN GOTO GETSLOPE
   idcnt = 5
  EXIT DO
 END IF

 IF NEWKEY$ = BS$ THEN
  IF idcnt > 0 THEN
```

```
RETURN

noslope:
PRINT "ERROR-SLOPE.CAL NOT FOUND"
PRINT "RUN RFCAL PRIOR TO OPERATION"
SYSTEM

'**********************machine id code*****************
NOMACHINEID:
GOSUB GETMACHINEID
GOTO continueinit

newmachineid:
GOSUB GETMACHINEID
'GOSUB SAVESLOPES:
GOTO continueinit

SAVESLOPES:
PRINT #1, ESC$;
CALL RCV
FOR i = 1 TO 6
 PRINT #1, "S" + LTRIM$(RTRIM$(STR$(i))) + LTRIM$(RTRIM$(STR$(slope(i)))) +
CR$
 CALL RCV
 SLEEP (1)
NEXT i
RETURN

GETMACHINEID:
idcnt = 0
MACHINEID$ = ""

VIEW PRINT 1 TO 2
LOCATE 2, 1
PRINT SPACE$(79);

LOCATE 2, 1
PRINT "Enter PRISM ID NUMBER (001 - 999) > ";
DO
DO
 CALL GETNEWKEY(NEWKEY$)
LOOP WHILE NEWKEY$ = ""

IF NEWKEY$ = CR$ THEN
 IF idcnt = 0 THEN GOTO GETMACHINEID
 IF idcnt = 1 THEN MACHINEID$ = "00" + MACHINEID$
 IF idcnt = 2 THEN MACHINEID$ = "0" + MACHINEID$
```

```
chnum = VAL(MID$(S$, 9, 1))
diffa = oldchana / 32 - S

    '...............

IF DEBUG THEN
   PRINT USING "####### # #####.## #####.##"; chana; chnum; S; diffa;
  IF j > 0 THEN PRINT USING "#####.##       "; (ABS((rdata(chan, j - 1, 1) - chana) / 32)) * 50 * 32 / slope(chan); ELSE PRINT "            ";
ELSE
  IF j > 0 THEN PRINT USING "    ###.## uL"; (ABS((rdata(chan, j - 1, 1) - chana) / 32)) * 50 * 32 / slope(chan);
END IF
    '.........................

SELECT CASE chan + 1
CASE 1: PRINT #1, "M4"
CASE 2: PRINT #1, "M1"
CASE 3: PRINT #1, "M3"
CASE 4: PRINT #1, "M0"
CASE 5: PRINT #1, "M5"
CASE 6: PRINT #1, "M2"
END SELECT
CALL RCV
CALL Delay(READDEL) 'delay for apres mux

 PRINT #1, "R"
CALL RCV

    '........

S$ = MID$(sbuff$, 3, 10) + " "
S = VAL(LEFT$(S$, 8)) / 32

oldchanb = chanb
chanb = VAL(LEFT$(S$, 7))
chnum = VAL(MID$(S$, 9, 1))
diffb = oldchanb / 32 - S

    '...............

IF DEBUG THEN
   PRINT USING "####### # #####.## #####.##"; chanb; chnum; S; diffb;
 IF j > 0 THEN PRINT USING "#####.##    "; (ABS((rdata(chan + 1, j - 1, 1) - chanb) / 32)) * 50 * 32 / slope(chan + 1); ELSE PRINT "            ";
 PRINT

ELSE
 IF j > 0 THEN PRINT USING "    ###.## uL "; (ABS((rdata(chan + 1, j - 1, 1) - chanb) / 32)) * 50 * 32 / slope(chan + 1);
 PRINT
END IF
```

```
END IF

DISSTART = 1
DISEND = ENDCNT

FOR i = DISSTART TO DISEND
        rarray(i, 4) = rarray(i, 2) * rarray(i, 2)
NEXT

GOSUB CALCULATE

GOSUB printit

CLOSE #2

RETURN

DBLREAD:
'********inner read loop

VIEW PRINT 14 TO 23

IF DEBUG THEN
 LOCATE 23, 1
ELSE
 LOCATE (14 + j), 1
 IF j > 0 THEN PRINT USING "     ##      "; j;
END IF

SELECT CASE chan
 CASE 1: PRINT #1, "M4"
 CASE 2: PRINT #1, "M1"
 CASE 3: PRINT #1, "M3"
 CASE 4: PRINT #1, "M0"
 CASE 5: PRINT #1, "M5"
 CASE 6: PRINT #1, "M2"
END SELECT

CALL RCV
CALL Delay(READDEL) 'delay for apres mux

PRINT #1, "R"
CALL RCV
   '********

S$ = MID$(sbuff$, 3, 10) + " "
S = VAL(LEFT$(S$, 8)) / 32

oldchana = chana
chana = VAL(LEFT$(S$, 7))
```

```
    END IF
   END IF
  END IF
 END IF

 PRINT " ";

 RETURN

 '************************

 ErrorRecover:
 PRINT "ERROR # -";
 PRINT ERR
 STOP

 '*****************
 ' START OF CALCULATIONS
 '*****************

 docalc:

 SCOUNT = 0
 skip = 0

 OPEN logfilename$ FOR APPEND AS #2
 PRINT #2,
 PRINT #2, "            PRISM RF VOLUME VALIDATION "
 PRINT #2, "PRISM " + MACHINEID$;
 PRINT #2, "    " + DATE$ + "    " + TIME$
 IF RMX THEN PRINT #2, " Channel "; channelnumber; " Pump " +
 PUMPLIST$(PUMPNUMBER)
 PRINT #2, " Cup number " + chan$;
 IF chan$ = "1" OR chan$ = "3" OR chan$ = "5" THEN PRINT #2, "  Sub-A" ELSE PRINT #2,
 "  Sub-B"

 IF DEBUG THEN
  PRINT #2, "INIT LOW  REF ,"; ref(chan, 1, 1)
  PRINT #2, "INIT HIGH REF ,"; ref(chan, 2, 1)

  PRINT #2, "FINAL LOW  REF,"; ref(chan, 1, 2)
  PRINT #2, "FINAL HIGH REF,"; ref(chan, 2, 2)

  FOR A = 0 TO ENDCNT
   PRINT #2. A, ;
    PRINT #2, USING " #####.#"; rarray(A, 1);
    PRINT #2, USING " #####.#"; rarray(A, 2)
  NEXT A
```

```
'    PRINT #2, " MEAN VOLUME > 52.5 uL  "

   END IF

   IF CV > 2 THEN
        PRINT " CV > 2%  "
        PRINT #2, " CV > 2%  "
   ELSE
        PRINT " CV > 1.5%"
        PRINT #2, " CV > 1.5%"
   END IF

  END IF
 END IF
ELSE
'*********HERE FOR SAMPLE MANAGER
IF PASS THEN
  PRINT " *PASS* ": PRINT #2, "  PASS "
END IF

IF NOT PASS THEN
   PRINT "***FAIL-"; : PRINT #2, "  FAIL ";

   IF (vol < 47.5) THEN
    PRINT "VOL < 47.5 uL";
    PRINT #2, " MEAN VOLUME < 47.5 uL  "

'    IF (vol < 45.5) THEN
'     PRINT "VOL < 45.5 uL";
'     PRINT #2, " MEAN VOLUME < 45.5 uL  "

  ELSE
    IF (vol > 52.5) THEN
     PRINT "VOL > 52.5 uL";
     PRINT #2, " MEAN VOLUME > 52.5 uL  "

'     IF (vol > 54.5) THEN
'      PRINT "VOL > 54.5 uL";
'      PRINT #2, " MEAN VOLUME > 54.5 uL  "

  END IF

  IF CV > 9 THEN
       PRINT " CV > 9%  "
       PRINT #2, " CV > 9%  "
' ELSE
'      PRINT " CV > 1.5%"
'      PRINT #2, " CV > 1.5%"
  END IF
```

```
END IF

vol = mean * 50 / slopecal
CV = (stdev / mean) * 100

PASS = 0
'

STEP 17
IF NOT PUMPNUMBER = 9 THEN
 IF (vol >= 48) AND (vol <= 52) AND (CV <= 2) THEN PASS = -1
' IF (vol >= 48.5) AND (vol <= 51.5) AND (CV <= 2) THEN PASS = -1
' IF (vol >= 48!) AND (vol <= 52!) AND (CV <= 1.5) THEN PASS = -1
' IF (vol >= 47.5) AND (vol <= 48!) AND (CV <= (1 - (48 - vol) * 2)) THEN PASS = -1
' IF (vol >= 52!) AND (vol <= 52.5) AND (CV <= (1 - (vol - 52!) * 2)) THEN PASS = -1
ELSE
'*******HERE FOR SAMPLE MANAGER
 IF (vol >= 47.5) AND (vol <= 52.5) THEN PASS = -1
 ' IF (vol >= 45.5) AND (vol <= 54.5) AND (CV <= 9) THEN PASS = -1
 'IF (vol >= 48!) AND (vol <= 52!) AND (CV <= 1.5) THEN PASS = -1
 'IF (vol >= 47.5) AND (vol <= 48!) AND (CV <= (1 - (48 - vol) * 2)) THEN PASS = -1
 'IF (vol >= 52!) AND (vol <= 52.5) AND (CV <= (1 - (vol - 52!) * 2)) THEN PASS = -1

 END IF

 IF RMX THEN
  IF NOT PUMPNUMBER = 9 THEN
   IF PASS THEN
    PRINT " *PASS* ": PRINT #2, "  PASS "
   END IF

   IF NOT PASS THEN
    PRINT "***FAIL-"; : PRINT #2, "  FAIL ";

     IF (vol < 48) THEN
      PRINT "VOL < 48 uL";
      PRINT #2, " MEAN VOLUME < 48 uL "

'     IF (vol < 47.5) THEN
'      PRINT "VOL < 47.5 uL";
'      PRINT #2, " MEAN VOLUME < 47.5 uL "

     ELSE
      IF (vol > 52) THEN
       PRINT "VOL > 52 uL";
       PRINT #2, " MEAN VOLUME > 52 uL "

'      IF (vol > 52.5) THEN
'       PRINT "VOL > 52.5 uL";
```

```
NEXT
runmean = mean
sumsq = runmean * runmean

mean = mean / meannum

stdev = SQR((meannum * meansq - sumsq) / (meannum * meannum))

FOR i = (DISSTART) TO (DISEND)
     rarray(i, 3) = -(mean - rarray(i, 2))
NEXT

RETURN

printit:

STEP 15
FOR i = DISSTART TO DISEND
IF DEBUG THEN
 PRINT USING " ######     #####.#      #####.#       ###.## uL"; rarray(i, 1):
rarray(i, 2); rarray(i, 3); rarray(i, 2) * 50 / slopecal
  PRINT #2, USING "######.,#####.#,####.#,###.##,uL"; rarray(i, 1);
rarray(i, 2); rarray(i, 3); rarray(i, 2) * 50 / slopecal
ELSE
 PRINT USING "          ###.## uL"; rarray(i, 2) * 50 / slopecal
 PRINT #2, USING "###.##,uL"; rarray(i, 2) * 50 / slopecal
END IF
NEXT

STEP 16
IF DEBUG THEN
 PRINT USING " Mean = ####.# counts ###.## uL PerCent CV =##.##%"; mean;
mean * 50 / slopecal; (stdev / mean) * 100
 PRINT USING " StDev = ###.## counts ###.## uL No. of Reads =##   "; stdev; stdev
* 50 / slopecal; meannum;
  PRINT #2, USING "Mean =,####.#,counts,###.##,uL,PerCent-CV=,##.##,%";
mean; mean * 50 / slopecal; (stdev / mean) * 100
  PRINT #2, USING "StDev=,##.##,counts,###.##,uL,Number-Reads=,##"; stdev;
stdev * 50 / slopecal; meannum;
ELSE
 PRINT USING " Mean =  ###.## uL PerCent CV  =##.##%"; mean * 50 / slopecal;
(stdev / mean) * 100
 PRINT USING " StDev =  ###.## uL No. of Reads =##   "; stdev * 50 / slopecal;
meannum;
 PRINT #2, USING "Mean =,###.##,uL,PerCent-CV=,##.##,%"; mean * 50 / slopecal;
(stdev / mean) * 100
 PRINT #2, USING "StDev=,###.##,uL,Number-Reads=,##"; stdev * 50 / slopecal;
meannum;
```

```
END IF
FOR j = 0 TO ENDCNT
  IF j > 0 THEN rarray(j, 2) = rdata(chan + 1, j, 3) ELSE rarray(j, 2) = 0
  rarray(j, 1) = rdata(chan + 1, j, 1)
NEXT
chan$ = chanb$
GOSUB docalc
PASSB = PASS

IF NOT RMX THEN
 IF traycal THEN
  GOSUB GETSLOPE
   slope(chan + 1) = (slope(chan + 1) / VAL(NEWSLOPE$)) * vol '???
  GOSUB SAVESLOPES
 END IF

END IF

'**********end of system well-pair loop
CLOSE #1
'*******************RMX    Parallel    ****************

IF PASSA AND PASSB THEN RESULT = 1
IF NOT PASSA AND NOT PASSB THEN RESULT = 0
IF PASSA AND NOT PASSB THEN RESULT = 2
IF NOT PASSA AND PASSB THEN RESULT = 3
IF RMX THEN
 CALL sendrmx(RESULT)
END IF
'*******************RMX    Parallel    ****************

LOCATE 24, 1
SYSTEM

errorhandler:

PRINT USING "ERROR ### - PROGRAM HALTED ***"; ERR
STOP

CALCULATE:
mean = 0
meansq = 0

meannum = DISEND - DISSTART + 1

STEP 14
FOR i = (DISSTART) TO (DISEND)
    mean = mean + rarray(i, 2)
    meansq = meansq + rarray(i, 4)
```

```
 PRINT NEWKEY$
END IF

' CLS
IF RMX THEN
PRINT " PRISM " + MACHINEID$ + "    File-" + logfilename$ + "    Channel ";
channelnumber; "    " + PUMPLIST$(PUMPNUMBER) + " Pump    " + DATE$
ELSE
 PRINT "  PRISM " + MACHINEID$ + "              File-" + logfilename$ + "            " +
DATE$
END IF

slopecal = slope(chan)
PRINT
PRINT "CUP " + chana$;
IF DEBUG THEN
 PRINT USING " A-CNTS  DIFF   VAR FROM MEAN   VOLUME W/SLOPE =#####.#
COUNTS/50 uL"; slopecal
ELSE
 PRINT "      Sub-A VOL"
END IF

 FOR j = 0 TO ENDCNT

STEP 13
   IF j > 0 THEN rarray(j, 2) = rdata(chan, j, 3) ELSE rarray(j, 2) = 0
   rarray(j, 1) = rdata(chan, j, 1)
 NEXT
 chan$ = chana$
 GOSUB docalc
 PASSA = PASS
'**********

  IF traycal THEN
 GOSUB GETSLOPE
   slope(chan) = (slope(chan) / VAL(NEWSLOPE$)) * vol   '???

 END IF
'**********


PRINT
slopecal = slope(chan + 1)
PRINT "CUP " + chanb$;
IF DEBUG THEN
 PRINT USING " B-CNTS  DIFF   VAR FROM MEAN   VOLUME W/SLOPE =#####.#
COUNTS/50 uL": slopecal
ELSE
 PRINT "      Sub-B VOL"
```

```
'********************RMX    Parallel    *****************

END IF
'********************RMX    Parallel    ****************

'********************    BENCH    *****************
IF BENCH THEN
 CALL BENCHDISP
END IF
'********************    BENCH    *****************

STEP 11
NEXT
'end of outer read loop
'*******************GET   REFERENCE   READINGS**********************
VIEW PRINT 3 TO 5
CLS (2)

STEP 12
CALL GETREFS(startlow$, starthigh$)
ref(chan, 1, 2) = VAL(LEFT$(startlow$, 7))
ref(chan, 2, 2) = VAL(LEFT$(starthigh$, 7))

'*************END OF CHANNEL DATA COLLECTION

VIEW PRINT 1 TO 25
CLS

FOR j = 0 TO ENDCNT
  IF j > 0 THEN rdata(chan, j, 3) = rdata(chan, j, 1) - rdata(chan, j - 1, 1)
  IF j > 0 THEN rdata(chan + 1, j, 3) = rdata(chan + 1, j, 1) - rdata(chan + 1, j - 1, 1)
NEXT

IF DEBUG THEN
 PRINT "INIT  LOW  REF = "; ref(chan, 1, 1); "INIT  HIGH REF = "; ref(chan, 2, 1)
 PRINT "FINAL LOW  REF = "; ref(chan, 1, 2); "FINAL HIGH REF = "; ref(chan, 2, 2)
END IF

'***** START OF CALCULATIONS

IF NOT RMX THEN
 traycal = 0
 PRINT "IS THIS A TRAY CALIBRATION RUN (Y/N) >";
 DO
  CALL GETNEWKEY(NEWKEY$)
 LOOP WHILE NEWKEY$ = ""
 NEWKEY$ = UCASE$(NEWKEY$)
 IF (NEWKEY$ = "Y") THEN traycal = -1
```

```
'*******LOOK FOR DISPENSE
DO
STEP 8
 GOSUB DBLREAD
 CALL GETNEWKEY(NEWKEY$)
 LOOP WHILE ABS(diffa) < DIFF AND ABS(diffb) < DIFF

END IF

DIFFCNT = 0

'*******LOOK FOR SETTLING AFTER DISPENSE
DO
 GOSUB DBLREAD 'get a,b adc values
 IF j = 0 THEN GOSUB DBLREAD
 IF j = 0 THEN GOSUB DBLREAD: EXIT DO

STEP 9
IF ABS(diffa) < DIFF AND ABS(diffb) < DIFF THEN DIFFCNT = DIFFCNT + 1 ELSE DIFFCNT =
0
IF DIFFCNT = DIFFREPS THEN EXIT DO
CALL GETNEWKEY(NEWKEY$)
LOOP WHILE NEWKEY$ = ""

'*******SAVE READ

STEP 10
 rdata(chan, j, 1) = chana
 rdata(chan + 1, j, 1) = chanb

 'PRINT CHR$(7); BELL
BEEP
PRINT
 CALL Delay(500)
DO
LOOP WHILE INKEY$ <> "" 'WAIT FOR ANY ECHO

'********************RMX Parallel ****************
IF RMX THEN
 CALL sendrmx(1)    'valid read

'********************RMX Parallel ****************
DO
 CALL getrmx
LOOP WHILE rmxrcv < 3 OR rmxrcv > 4   'look for dispense start
IF DEBUG THEN PRINT " Received PRISM Start Dispense Command"
 rmxprime = -1
```

```
CALL GETNEWKEY(NEWKEY$)
IF (ABS(diffa) > PRIMESTART) OR (ABS(diffb) > PRIMESTART) THEN DIFFCNT = DIFFCNT
+ 1 ELSE DIFFCNT = 0
' DIFFCNT = 5

'******************** BENCH ******************
IF BENCH THEN
 CALL BENCHDISP
END IF
'******************** BENCH ******************

LOOP WHILE DIFFCNT < PRSTARTCNT

 DIFFCNT = 0

'*******LOOK FOR SETTLING AFTER DISPENSE
DO
 GOSUB DBLREAD 'get a,b adc values

STEP 6
 IF ABS(diffa) < PRIMEDIFF AND ABS(diffb) < PRIMEDIFF THEN DIFFCNT = DIFFCNT + 1
ELSE DIFFCNT = 0
 IF DIFFCNT > PRIMEREPS THEN EXIT DO
 CALL GETNEWKEY(NEWKEY$)
LOOP WHILE NEWKEY$ = ""

'*******************GET REFERENCE READINGS**********************
 PRINT #1, ESC$;
 CALL RCV

STEP 7
 CALL GETREFS(startlow$, starthigh$)
 ref(chan, 1, 1) = VAL(LEFT$(startlow$, 7))
 ref(chan, 2, 1) = VAL(LEFT$(starthigh$, 7))
 PRINT #1, ESC$;
 CALL RCV

'*******************GET READINGS OF 50 uL DISPENSES****************
FOR j = 0 TO ENDCNT
 VIEW PRINT 4 TO 5
 IF j > 0 THEN
   CLS (2)
IF (RMX OR BENCH) THEN PRINT "          PRISM NOW DISPENSING"; ELSE PRINT ; "
DISPENSE";
  PRINT " 50 uL INTO CUPS " + chana$ + " AND " + chanb$;

IF (RMX OR BENCH) THEN PRINT " - PLEASE WAIT" ELSE PRINT " THEN WAIT FOR BEEP
WHILE READS STABILIZE"
  PRINT "                    DISPENSE NUMBER "; j;
```

```
CALL DISPTRAY(chan)

VIEW PRINT 14 TO 23
LOCATE 23, 1

rmxprime = 0

dispoff = -1

STEP 5
GOSUB DBLREAD

'********************          BENCH     ******************
 IF BENCH THEN
  CALL BENCHDISP
  CALL BENCHDISP
 END IF
'********************          BENCH     ******************

GOSUB DBLREAD

'********************          BENCH     ******************
 IF BENCH THEN
  CALL BENCHDISP
  CALL BENCHDISP
 END IF
'********************          BENCH     ******************

dispoff = 0

'*****************DISPLAY A,B CUP READS WHILE FILLING***************
'WHILE INKEY$ = ""
' GOSUB DBLREAD 'get a,b adc values
DIFFCNT = 0
'*******LOOK FOR DISPENSE
DO
GOSUB DBLREAD

'*********************RMX   Parallel   *****************
IF RMX AND (rmxprime = 0) THEN
DO
 CALL GETNEWKEY(NEWKEY$)
 CALL getrmx
 LOOP WHILE rmxrcv <> 2   'look for prime start
IF DEBUG THEN PRINT " Received PRISM Start Prime Command"
 rmxprime = -1
END IF
'*********************RMX   Parallel   *****************
```